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V. R. GARDNER, *Director* . . . . . J. G. DUNCAN, *Editor*

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents: (1) progress reports on long-term major research projects; (2) final reports on short-term projects and (3) short, timely articles of a popular nature that bring together information from various sources on subjects in which farmers are interested.

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TWO NEW VARIETIES OF OATS FOR MICHIGAN

By E. E. DOWN

SECTION OF FARM CROPS

TWO NEW VARIETIES of oats were increased in 1948 for introduction to Michigan farmers. Both of these varieties are the result of the combined effort of the Farm Crops Department of Michigan State College and members of the Office of Oat Investigations of the U. S. Department of Agriculture.

The services of the Office of Oat Investigations have been of great value in the development of these varieties. Material for breeding purposes is collected from all parts of the world and tested for disease resistance. Resistant material is combined or crossed with old varieties to produce new and better genetic combinations of oat characters for this country. Material in varying degrees of genetic purity resulting from these crosses is sent to interested state agricultural experiment stations for testing and further selection. A large number of recently introduced varieties have been developed in this manner. This is also true of the two varieties described herein.

Kent and Bonham are the names given two new varieties of oats increased for the first time in 1948. They were selected from a cross made between Bond and D69. The Eaton variety, familiar to many Michigan growers, has Bond as one of its parents. Bond is an Australian variety, highly resistant to smut and most of the common forms of leaf or crown rust. However it is susceptible to leaf rust strain No. 45 that is increasing in importance in the corn belt states. D69 is the number given a selection from a cross between Richland and Green Russian oats. D69 is resistant to the common forms of stem rust that appear in Michigan. Both Kent and Bonham carry rust resistance similar to the yellow Clinton variety from Iowa.

Kent is a high-yielding, early-maturing, white-grained variety, medium in straw length, and having a high test weight. The straw is slightly weaker than that of Eaton, at least in some years and in some sections of the state.

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TABLE 1—*Agronomic comparison at East Lansing of Eaton, Huron, Kent and Bonham oat varieties*

Variety	1941	1942	1943	1944	1945	1946	1947	1948	Average
Yield in bushels per acre									
Eaton	75.5	95.4	47.9	77.1	85.2	81.2	78.1	74.6	76.9
Huron	76.8	95.5	37.0	81.0	79.6	84.8	72.0	89.1	77.0
Kent	76.5	98.5	40.9	83.0	84.9	82.7	71.8	74.9	76.7
Bonham	.....	.....	.....	.....	.....	.....	64.4	70.6	*67.5
Test weight in pounds per bushel									
Eaton	35.7	34.0	29.5	35.3	36.4	36.7	32.3	34.9	34.4
Huron	37.5	36.3	28.8	39.0	37.6	36.8	34.4	37.7	36.0
Kent	38.5	36.0	34.5	37.5	37.8	39.6	35.9	37.3	37.1
Bonham	.....	.....	.....	.....	.....	.....	32.7	36.0	*34.4
Date in July when ripe									
Eaton	11	18	24	14	26	17	23	13	18
Huron	15	20	24	21	26	19	23	13	20
Kent	14	18	24	14	26	17	23	13	19
Bonham	.....	.....	.....	.....	.....	.....	23	13	*18
Height in inches									
Eaton	37	45	40	41	42	44	37	44	41.3
Huron	39	50	42	45	45	47	39	51	44.8
Kent	37	46	40	40	43	44	40	43	41.6
Bonham	.....	.....	.....	.....	.....	.....	40	43	*42.0
Lodging, in percent									
Eaton	0	4	0	0	0	0	0	0	0.5
Huron	0	10	15	0	0	0	0	3	4.5
Kent	0	4	5	0	0	0	0	0	1.0
Bonham	.....	.....	.....	.....	.....	.....	0	0	*0

*2-year average.

Kent is recommended especially for the "Thumb" and Saginaw Valley where a white-grained variety with a high test weight is desirable. It should be planted after corn or sugar beets. It should be adapted to other parts of the lower peninsula where lodging is not too serious. It is not intended that the Kent variety should replace Eaton in Michigan. It should be a good replacement for Huron since it has as high a test weight and has rust resistance that Huron lacks.

Bonham is a high-yielding, smut- and rust-resistant, and early-maturing reddish-yellow-grained variety, medium in straw height, with high test weight. It is recommended for the upper peninsula. This variety was selected at the Upper Peninsula Experiment Station at Chatham by a former staff member, Evert Vandermulen. Increase of

the selections and testing in 1947 and 48 were made at the East Lansing station. At present, information on this variety indicates that its growth should be limited to conditions similar to those in the upper peninsula.

Fortunately, Kent and Bonham like Eaton are resistant to the new root-rot disease *(Helminthosporium victoriae)* that is doing so much damage. This disease was observed officially in Michigan in 1948 in the southern three tiers of counties. Many fields of Vicland were practically worthless in these counties.

SEED SUPPLY

Kent and Bonham varieties are being released through the Michigan Crop Improvement Association. Seed of Kent will be allocated to Michigan producers of certified seed and to others interested in certification. The same is true of Bonham, except distribution will be limited to upper peninsula growers.

Some 80 and 16 acres of Kent and Bonham respectively passed field inspection in 1948. Field returns have not been received on Bonham, but one field of 18 acres of Kent on the Herbert Gettel farm near Pigeon yielded 101 bushels per acre of 38-pound oats (uncleaned).

THE EFFECT OF IRRIGATION ON THE HUMIDITY IN ORCHARDS

By F. W. PEIKERT and R. T. TRIBBLE
SECTION OF AGRICULTURAL ENGINEERING

THE QUESTION is sometimes raised as to whether sprinkler irrigation in orchards will cause the spread of certain fungus diseases. The reason for this concern is that periods of high humidity are considered favorable for the spread of such diseases.

A study was made during August 1948, in an apple orchard in Van Buren County, Michigan, to compare the humidity in the immediate vicinity of irrigation with that in the surrounding orchard.

CONDITIONS PRESENT IN AREA OF STUDY

The data were collected in a mature apple orchard with heavy sod cover on a gently rolling topography that was being irrigated by a conventional portable pipe sprinkler system. This equipment consisted of a single line of pipe laid on the surface of the ground with revolving sprinklers spaced 42 feet, and each discharging about 20 gallons per minute. The nozzles of these sprinklers were about one foot above the pipe and the discharge from each sprinkler covered a diameter of about 120 feet. The irrigation line was allowed to run 4 hours in one location and then moved over 60 feet to a parallel position. Since the sprinklers were of the conventional field type, the stream of water reached a maximum height of about 10 feet above the ground in trees that averaged 20 to 25 feet tall. The sprinklers were of the two-nozzle type and made about one revolution per minute so that over most of the wetted circle the stream of water hit any one location of the foliage only a few seconds during each revolution.

Throughout the period of test it was partly cloudy. The wind velocity varied from about 2 to 3½ miles per hour and the direction was NNW to NNE. The line of sprinklers was set in a north-south direction. Further details of the weather are shown in Table 1.

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TABLE 1—*Weather conditions during test period*

Time	Wind direction	Wind velocity m.p.h.	Temperature	Relative humidity (percent)
8:00 a.m.	NNW	3.4	69	76
9:05	NNW	3.2	71	66
9:15	NNW	2.7	73	65
9:50	NNW	3.4	76	66
10:30	NNW	2.9	77	65
11:00	N	2.0	80	57
11:30	NNE	2.4	80	60
11:44	NNE	2.3	81	58
1:04 p.m.	NNE	2.4	82	44
1:31	NNE	2.5	83	46
1:49	NNE	2.5	82	49
2:15	NNE	2.0	81	54
2:45	NNE	1.9	76	55
3:15	NNE	1.9	75	58
3:30	NNE	2.2	74	60

METHOD OF MAKING STUDY

A number of stations were set up along several lines taken perpendicular to the pipe and sprinklers. These stations were all located adjacent to trees and at 3-, 10- and 15-foot levels above the ground. The locations with respect to the sprinklers were at the tree nearest to the irrigation line and at 60-, 120-, 180- and 240-foot distances.

Initial readings of temperature and humidity were taken in the morning prior to starting irrigation and then at approximately one-half hour intervals while the system was in operation and continued after shutting down until the humidity in the irrigated zone was again the same as the surrounding area.

RESULTS

During Irrigation

Figure 1 shows the average relative humidity along a representative line of stations during the irrigation period. Readings were taken at each of the three levels and at different distances from the sprinklers.

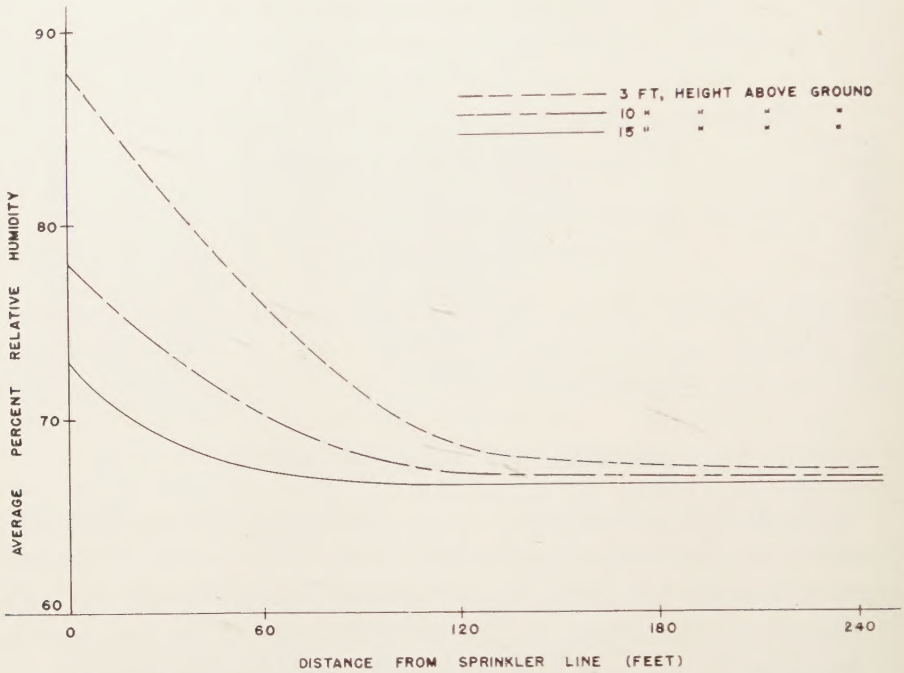

Fig. 1. Humidity variation in orchard during sprinkler irrigation.

Table 2 shows that the increase in relative humidity was considerable at all three levels immediately adjacent to the sprinklers. At a distance of 60 feet, the farthest that any of the water was distributed from the sprinklers, there was an increase in humidity of 9 percent at the 3-foot level, 3 percent at the 10-foot level and 1 percent 15 feet above the ground. Any water passing through the air at this location was practically at ground level.

TABLE 2—*Variation in humidity above normal due to irrigation*

Elevation above ground	Distance in feet from sprinkler line		
	0	60	120
	Percent	Percent	Percent
3	21	9	0
10	11	3	0
15	6	1	0

One hundred and twenty feet away from the sprinklers the irrigation had no apparent effect on the humidity even though the wind was blowing somewhat from the general direction of the irrigation line.

These results seem to indicate that any increase in humidity due to irrigation is confined within the approximate area covered by the sprinklers.

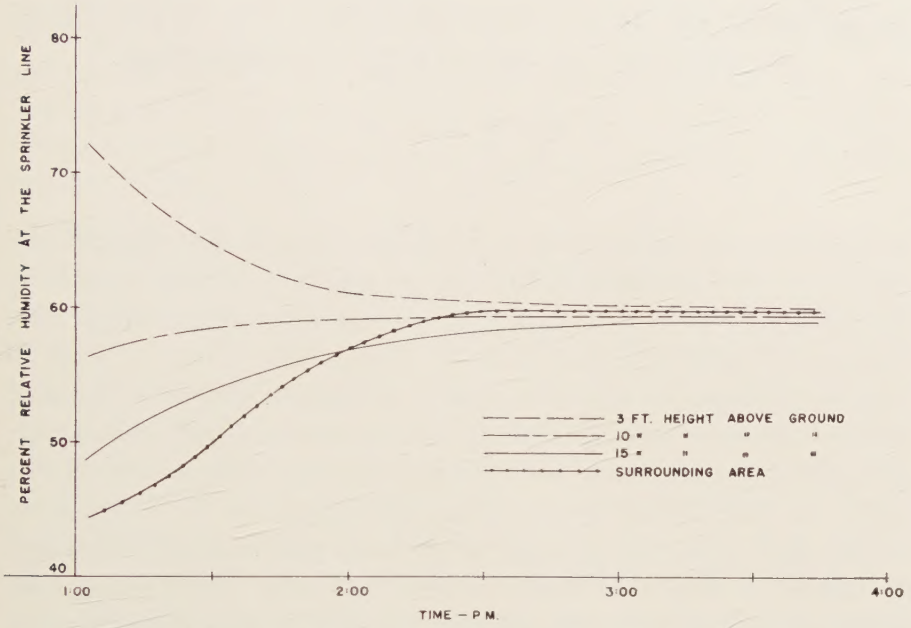

Fig. 2. Humidity variation in orchard after sprinkler irrigation.

After Irrigation

After the sprinkler line was shut off, frequent readings were taken at the line of sprinklers to determine how rapidly the humidity would return to normal. Figure 2 shows the results obtained at a typical station compared to the surrounding unirrigated area.

At the time that the first of these observations were made, the humidity of the surrounding area was considerably lower than at the test station but increased rather rapidly during the next 2 hours. Under the conditions observed, the humidity in the irrigated zone returned to approximately normal in a period of one hour. Within 45 minutes after irrigation the foliage on the trees was completely dry but some drops of water still remained on the fruit.

REACTION OF POTATO VARIETIES TO INFECTION BY *FUSARIUM EUMARTII* CARPENTER

By J. H. MUNCIE

SECTION OF BOTANY AND PLANT PATHOLOGY

POTATO FUSARIUM wilt caused by *Fusarium eumartii*, first described by Carpenter (1) and later more fully treated as a serious disease in Pennsylvania (7) is now known in several states, particularly New York (4, 5) and Nebraska (2, 3, 6). It has been known at least 20 years in Michigan, as shown by a study of organisms found in diseased tubers.* However, until recently the disease occurred only sporadically and probably was present in only trace amounts as far as our records show. In 1946, wilted potato plants were found by L. C. Knorr in certain areas of the northern part of the lower peninsula and diagnosed by him as "Z" disease as known in New York state. Later plants with symptoms typical of the disease were found in widely scattered areas in the state, including one county in the upper peninsula. In some fields losses ranged from 10 to 25 percent of the plants, although in most cases infected plants were not abundant but were scattered through the field. Although the disease was first found affecting the Russet Rural variety, it has since been found on most of the commercial varieties in the state.

In Nebraska, Goss and Jensen (3) and Jensen and Goss (6) in 1941 tested several commercial varieties and first-year seedlings for resistance to *Fusarium eumartii*. Since many new varieties have been developed since that time it was thought desirable to determine varietal susceptibility of the common commercial varieties grown in Michigan as well as to test certain unnamed seedling varieties being grown in our program for potato improvement.

*Verbal communication from M. C. Strong, Botany and Plant Pathology Department.

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GREENHOUSE TRIALS

Materials and Methods

Since many hybrid varieties are being developed and tested in Michigan for resistance to potato scab, several of these as well as commercial varieties were employed in greenhouse or field tests. The greenhouse test included 25 seedlings and the commercial varieties, Chippewa, Irish Cobbler, Russet Rural, Bliss Triumph, Katahdin, Sebago and Menominee.

Steamed soil was inoculated with the fungus grown on sterilized oats and in liquid culture. The soil was allowed to stand one week, thoroughly mixed and placed in steamed pots. One cut seed-piece was planted in each pot. After the plant was about 4 inches high the small roots around the edge of the pot were cut with a sterilized knife to provide wounds for more rapid entry of the organism. Four strains of the fungus were used, one pot of each series being inoculated with each strain. Three of the strains were received from C. A. Thomas, Cornell University, and the fourth was taken from the stock culture of the department and previously determined by C. D. Sherbakoff as *Fusarium eumartii*. Subsequent to these tests the fungus was isolated from Michigan-grown tubers.

Foliage symptoms were noted at frequent intervals and final readings were made 6 weeks after planting. Degree of infection was rated from 0 to 4 (none to severe with wilting and mottling of the foliage). Because greenhouse space was needed for other experiments, the tubers were harvested 8 weeks after planting. Each tuber was examined for stem-end rot and cut to determine vascular discoloration.

Results

Results of these tests are given in Table 1 and show that all commercial varieties and seedlings except Katahdin were affected under greenhouse conditions. Of the 26 seedlings, 13 showed tuber symptoms in addition to the varieties Chippewa, Bliss Triumph and Menominee. There was also considerable difference in ability of the different strains of the fungus to produce symptoms on the same potato variety. It is interesting to note that culture 215, carried in stock for 20 years, was still pathogenic.

TABLE 1—*Reaction of potato varieties to Fusarium eumartii in greenhouse trials*

Seedling parentage or commercial variety	Degree of foliage symptoms	Percentage tubers infected
Hindenburg x Katahdin	+ + + +	13.3
A F Y-5 x 528-34	+ + + +	12.5
A F Y-5	+ + + +	22.2
159-1 x Katahdin	+ + +	15.4
Hindenburg x 528-170 X Hindenburg x Katahdin	+ + + +	0.0
Chippewa x (Hin. x Katahdin)	+ + +	0.0
245-36 x (Hin. x 4-34-1-1)	+ + +	42.5
Chippewa x (Hin. x 528-170)	+ + +	6.3
245-252 x Menominee	+ + +	0.0
Hin. x 528-170 x (Menominee)	+ + +	0.0
Jubel x 245-36	+ + + +	20.0
R. Rural x 528-102 x (Katahdin)	+ + +	0.0
Arnica x 528-34	+ + + +	3.5
R. Rural x (Ostragis) x Menominee	+ + +	0.0
627-618 x Ostragis	+ + +	0.0
(627-618 x 8-1) x K 38-22	+ + +	10.0
627-618 x 245-36	+ + +	3.5
Chippewa x Menominee	+ +	0.0
Erie x Menominee	- - -	15.4
245-252 x (Hin. x Katahdin)	+ + + +	3.4
Sebago x 528-170	+ + + +	18.2
Chippewa x (Hin. x Katahdin)	+ + + +	6.6
Russet Rural	+ + +	0.0
Sebago	+ +	0.0
Menominee	- - -	30.4
Bliss Triumph	+ + + +	41.6
Chippewa	+ + +	25.0
Irish Cobbler	+ + + +	0.0
Katahdin	- -	0.0

FIELD TRIALS

Materials and Methods

Further tests were made with other lots of seedlings and an increased number of commercial varieties at the Lake City Experiment Station in 1948. Steamed soil, inoculated with the foregoing strains of the fungus, was spread in freshly opened furrows, and the cut seed-pieces of each variety were planted by hand and immediately covered. In these tests, 24 unnamed seedlings and the commercial varieties, Menominee, Russet Rural, Erie, Pontiac, Sebago, Katahdin, Russet Burbank, White Rural, Irish Cobbler, Green Mountain, Chippewa, Bliss Triumph, Teton, Sequoia and Kennebec were employed.

The field on which this test was carried out adjoined a pond so that the water table was relatively high during the growing season. In addition, the field was overhead-irrigated four times during the season from July 25 to September 20, during a protracted drought.

Results

Results of these tests are given in Table 2, showing the reaction of the varieties as to foliage symptoms and tubers infected at harvest time. The field was planted May 17, and harvested September 22.

TABLE 2—*Reaction of potato varieties to Fusarium eumartii in field trials*

Seedling parentage or commercial variety	Percentage with foliage symptoms	Percentage with tuber infection
Ostragis x Katahdin	77.6	64.1
Jubel x 245-186	63.3	77.2
46110 x 627-218	53.3	33.7
Hindenburg x 528-170	48.3	39.4
528-102 x Katahdin	65.0	33.2
K 35-6 x 528-274	31.6	24.4
627-618 x Ostragis	51.6	36.2
Sebago x 528-170	78.3	10.6
627-618 x 245-36	20.0	33.0
Menominee x Ostragis	5.0	38.1
Hindenburg x Katahdin (1)	76.6	20.5
Hindenburg x Katahdin (2)	63.3	32.3
528-274 x 627-218	45.0	17.7
125-4 (U.S.D.A.)	28.5	32.6
24-3 (U.S.D.A.)	35.0	30.8
627-49 (U.S.D.A.)	18.6	31.9
529-2 (U.S.D.A.)	35.0	40.0
520-11 (U.S.D.A.)	48.0	100.0
627-126 (U.S.D.A.)	51.6	11.4
53-11 (U.S.D.A.)	16.6	28.0
Maine-Leaf roll resistant	60.0	27.0
Menominee	45.0	52.8
Pontiac	33.3	18.5
Erie	43.3	23.9
Russet Rural	61.6	29.2
Katahdin	5.8	23.5
Sebago	6.6	52.5
Russet Burbank	55.0	46.0
Irish Cobbler	51.6	32.6
White Rural	40.0	39.8
Green Mountain	15.0	64.8
Chippewa	30.0	31.8
Sequoia	20.0	23.1
Kennebec	61.6	23.5
Teton	48.2	9.2
Bliss Triumph	71.6	28.0
Russet Rural x Ostragis	66.3	25.2
245-36 x (Hindenburg x 4-34-1-1)	45.0	66.6

Because of lack of sufficient seed and also inoculum, only one row of 60 hills of each variety was planted.

In making readings on the tubers, it was found that in many cases the only sign of infection was a lead-colored discoloration at the stem end. However, on clipping the stem end of the tuber, there usually was the typical yellow-brown discoloration of the flesh adjacent to the vascular ring and a darker browning of the vascular ring extending deeply into the tuber.

From these tests of only one year, but under conditions very favorable for development of the disease, certain varieties showed considerable ability to withstand infection. This may be resistance or in certain cases only disease escape. The results however give an indi-

cation of the comparative reaction of the varieties under field conditions of heavy soil infestation with *Fusarium eumartii*. Such areas are present in the state and under these conditions the results should indicate to the grower what may be expected of certain commercial varieties.

If reaction to tuber infection is classified into grades of 10 percent intervals, then the Teton variety is outstanding in freedom from disease. Varieties falling into grades of 11 to 20 percent include the unnamed seedling selections from crosses Sebago X 528-170, 627-618X Ostragis, Hindenburg X Katahdin, 528-274X627-218, 627-126 (U.S.D.A.) and Pontiac. Most of the unnamed seedling selections fall into the groups showing 21 to 40 percent infection, while a few are found within the grades 41 to 60 percent.

These results indicate that considerable progress in control of the wilt disease may be made by breeding and, where feasible, similar and more extensive tests should be carried on in connection with those for resistance to scab and other diseases.

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A MODIFIED WET AND DRY-BULB THERMOMETER TECHNIQUE FOR DETERMINING THE MOISTURE CONTENT OR STORAGE QUALITIES OF SO-CALLED DRY MATERIALS

By S. T. DEXTER
SECTION OF FARM CROPS

GRAINS, HAY and other perishable materials heat, mold and spoil readily if stored at too high a moisture content. Although this critical moisture content varies considerably with the material in question, the relative humidity of the surrounding atmosphere at which molding will readily occur seems to be a rather constant value, about 80 percent. Thus, damp grain does not mold if surrounded by dry air. But damp grain will bring the storage atmosphere very quickly to a high relative humidity if there is no ventilation; drier grain will bring it to a lower relative humidity, while very dry grain may even take moisture out of the air. Molding occurs only when the air in the storage compartment reaches a high relative humidity. This paper describes a method by means of which we are able to determine the relative humidity that a sample will build up in storage, with the use of a small sample.

In a series of papers (1), (2), (3), (4), and others, it has previously been shown that:

1. Most common "dry" materials, such as grain, hay, tobacco, paper, and wood, will come to definite moisture equilibria in air at various relative humidities.

2. There is likely to be considerable difference in the moisture contents of these various materials even though they are stored together in the same container, at any given relative humidity. Materials similar in composition are usually similar in moisture-equilibria relationships.

3. The air surrounding a quantity of any one of these materials in a closed container will, on shaking the container, come promptly to

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a relative humidity closely approximating the air-material equilibrium point. A negligible amount of moisture needs to be evaporated if the air is drier, or absorbed if the air is more humid than the equilibrium value.

4. Molds develop freely at ordinary temperatures in a relative humidity of 80-85 percent or higher.

5. Thus, to determine the keeping qualities, we have but to find the relative humidity of the air surrounding the sample (6).

6. The relative humidity that a saturated aqueous solution of any material such as a salt will establish or maintain in a closed container is a fixed figure, dependent upon the solubility, etc., of the salt. With common salt, sodium chloride, in saturated solution, this figure is 75-76 percent relative humidity (R.H.), with saturated calcium chloride solution giving 32 percent R.H. Thus, a saturated solution of common salt will not give off moisture in air at 80 percent R.H., nor calcium chloride at 50 percent R.H., but will, rather, take up moisture from the air at these respective humidities.

For many reasons, the ordinary devices used in determining relative humidity have not been found useful with small samples, although Gaus *et al.* (6) have reported a method useful with baled cotton. These devices generally require too much air, are slow to come to equilibrium, or readily lose their calibration. Two methods, previously reported, show how moisture contents can be estimated, by colorometric (5) or textural (3) appearances of certain chemicals.

THE MODIFIED WET AND DRY-BULB THERMOMETER METHOD

In the ordinary method of determining relative humidity by the wet and dry-bulb thermometer method, the wet bulb is moistened with water, which evaporates until the temperature of the bulb is reduced to such a temperature that the vapor pressure of the water cooled by evaporation on the bulb is the same as that of the atmosphere, and no more evaporation can take place. For example, in a room at 70° F. and 75 percent R.H., the wet bulb would read approximately 64.5° F., a cooling of about 6°. *At any temperature, and 75 percent relative humidity, a bulb moistened with saturated common salt solution would show no evaporation at all*, and no cooling.

If the dry and the wet bulbs were shaken up with wheat grain at about 15-percent moisture (which maintains a relative humidity of about 75 percent) they would show almost identical readings if the wet bulb were moistened with a saturated common salt solution. If the grain were at 14-percent moisture, the wet bulb would be cooled by evaporation; if the grain were at 16-percent moisture, the wet bulb would become heated above the temperature of the dry bulb. If there is only *slight* evaporation from the wet bulb, the relatively bulky sample of grain, with a relatively great surface, will be able to absorb the water vapor without difficulty, keeping the air at a (practically) constant relative humidity. Or if there is only *slight* absorption of water from the air by the wet bulb, the grain will be able to supply this small amount of water by evaporation and keep the humidity constant.

SELECTION OF THE APPROPRIATE SATURATED SOLUTION

Thus, a solution is selected for moistening the wet bulb that is suited to the range of humidities and moistures being tested, so that, in whatever case, only *slight* evaporation or absorption of water vapor will be required. For example, in the range around 15-percent moisture in wheat, sodium chloride is appropriate, for the highest accuracy and greatest convenience. At a value near 18-percent moisture, potassium chromate would be suitable, since it will maintain a relative humidity of 88 percent. Cupric chloride, 68 percent R.H. at equilibrium, would be excellent in ranges slightly below 13 percent, while magnesium chloride gives equilibrium at 32 percent R.H., and no cooling of the bulb in wheat at 9-percent moisture. At extremely dry ranges, zinc chloride gave no depression at 3.6-percent moisture in wheat. The chemical selected should, in each case, possess the characteristic of maintaining a constant relative humidity over a considerable range of temperature, as well as a relative humidity in the desired range. The ones enumerated are exceptionally well suited in this regard. Manganous chloride, about 54 percent R.H. and barium chloride, about 91 percent R.H., may also be mentioned as being especially constant. For further information see the International Critical Tables and, briefly, page 1397 in Lange's Handbook of Chemistry, 6th edition.

EXPERIMENTAL METHOD

Two thermometers, (range: 10 - 110° C.) were inserted in a large two-hole rubber stopper. On the bulb of one was placed a tight cloth bag, made of two layers of cheesecloth. This cloth was moistened with the solution. The dry-bulb thermometer extended about 4 inches through the stopper, and the wet bulb about 2 inches, to avoid any possible interference. The container was, usually, a 1000-cc. flask or a quart bottle, well wrapped with paper to avoid temperature disturbances on handling. With whole grain, the sample filled the container from one-third to one-half, thus allowing for easy shaking. About 300 grams of wheat, or 200 grams of oats was used. With materials with greater surface, such as sugarbeet pulp, or ground grains, or sawdust, samples as small as 50 grams were found to give the same temperatures as did larger samples.

Before inserting the thermometers into the bottle, the wet bulb was warmed with the fingers to approximately the temperature of the dry bulb. With the thermometers and stopper in place, the bottle was vigorously shaken for about 30 seconds, when a reading of the wet bulb was taken; additional readings were taken until the temperatures were constant. Usually a constant temperature was reached before 90 seconds of shaking had elapsed. If shaking must be continued for more than 2 minutes to obtain a constant temperature, it is likely that the sample is outside the best range of the solution being used. Although during these experiments, depressions or elevations of the temperatures of the wet bulb as great as 5 or 6° were obtained, and could be reliably duplicated, it seems desirable in practice, to avoid this excessive evaporation from the bulb or from the sample, since a more appropriate solution can conveniently be used.

Experimental Data

EXPERIMENT 1

Four saturated solutions, barium chloride, 91 percent R.H., ammonium chloride, 79 percent R.H., sodium chloride, 76 percent R.H., and potassium thiocyanate, 47 percent R.H., were made. Six lots of 300 grams each of wheat grain were mixed with 0, 3, 6, 9, 12 and 15 grams of water, respectively, and shaken repeatedly over a period of 10 days. These samples ranged from 11.20 percent to 15.37-percent moisture.*

*All moisture determinations were made by the Agricultural Chemistry Department after wet and dry bulb determinations were complete: 48 hours at 106 C. in an oven.

In the air in the laboratory, the wet bulb readings were approximately:

Water 17.4° C., barium chloride 19.0° C., ammonium chloride 20.5° C., sodium chloride 20.7° C., potassium thiocyanate 25.2° C., thus indicating successively less evaporation and less cooling, as would be expected.

When shaken with the six lots of wheat, in every case the same order resulted. These lots of wheat were used at four room temperatures, from about 30° C. down to 10° C. (86° F. to 50° F.), with essentially identical results. It should be remarked, however, that samples cannot be taken from one temperature and run immediately at another. For example, a cold sample in a burlap bag taken into a warm room was found to suffer condensation of moisture on its surface, and to give high-moisture-content readings. The bottle should be at the same temperature as the sample. Otherwise, it is impossible to arrive at a constant dry temperature reading of the air, and, if the bottle is cold, condensation on or in the bottle is likely to occur. Table 1 shows the results with the four chemicals.

TABLE 1—*The difference in temperature, Temperature of dry bulb (T_d) − Temperature of wet bulb (T_w), is given below for the six samples of wheat at the moisture contents shown. Results with the four saturated solutions indicated are given. If $T_d - T_w$ is positive, T_w is cooler than T_d. Negative values indicate heating of the wet bulb. For example, the top value for Barium Chloride is 29.5° C. − 23.7° C. = 5.8° C. The bottom value for potassium thiocyanate is 29.5° C. − 32.7° C. = −3.2° C. (the wet bulb heated)*

Moisture* in sample %	Td—Tw using the saturated solution on wet bulb						
	Barium chloride Td 29.5° C.	Ammonium chloride 29.5° C.	Sodium chloride 29.5° C.	Sodium chloride 24.8° C.	Sodium chloride 22.5° C.	Sodium chloride 11.0° C.	Potassium thiocyanate 29.5° C.
	Td—Tw	Td—Tw	Td—Tw	Td—Tw	Td—Tw	Td—Tw	Td—Tw
11.20	5.8	3.5	3.2	3.4	3.4	2.9	1.0
12.17	4.8	2.5	2.2	2.2	2.2	2.0	0.2
13.26	4.1	1.5	1.3	1.3	1.2	1.0	−0.4
13.67	3.5	0.8	0.6	0.6	0.7	0.6	−1.6
14.90	2.5	0.1	0.0	0.0	0.2	0.0	−2.5
15.37	2.1	−0.2	−0.4	−0.4	−0.3	−0.5	−3.2

*These samples were used for many tests, and moisture contents certainly changed somewhat in this extensive handling. These moisture determinations were made after the conclusion of the Td—Tw tests.

EXPERIMENT 2

Six lots of oats, six of barley, were run with saturated sodium chloride on the wet bulb. Table 2 shows these results.

TABLE 2—*Difference in bulb temperatures, $T_d - T_w$, is given for oats and barley and sugarbeet pulp samples with saturated sodium chloride solution on the bulb. Negative values show heating of the wet bulb*

Oat samples		Barley samples				Sugarbeet pulp	
Moisture percent	Td - Tw	Moisture percent	Td 24° C. Td - Tw	27.5° C. Td - Tw	25.7° C. Td - Tw	Moisture percent	Td - Tw
11.27	3.0	9.22	4.6	4.9	4.8	10.00	2.2
11.94	1.5	10.34	3.6	3.9	3.7	12.0	1.2
13.05	0.5	11.00	2.6	2.8	2.9	13.5	0.6
13.64	0.0	11.85	1.8	1.9	2.0	15.2	0.0
14.66	−0.5	12.77	1.1	1.0	1.2		
15.63	−1.0	13.82	0.4	0.4	0.5		

EXPERIMENT 3

Four presumably identical replicates A, B, C, and D, were made of samples of wheat at 5 moisture contents. These four identical samples were run, using four different solutions: a) potassium chromate, b) sodium chloride, c) cupric chloride, and d) magnesium chloride. Table 3 shows the results. Since the chemical determinations of moisture on these samples varied by several tenths of one percent in several cases, the average of the four replicates is used.

TABLE 3—*$T_d - T_w$ is given on 20 samples of wheat, five with each of the four chemicals shown*

Average moisture, four samples, percent	Saturated solution used on the wet bulb			
	Potassium chromate Td - Tw	Sodium chloride Td - Tw	Cupric chloride Td - Tw	Magnesium chloride Td - Tw
9.03	6.3	5.3	3.7	0.0
10.50	5.1	3.8	3.1	−1.4
12.01	3.4	2.4	1.6	−2.9
13.18	2.2	1.2	0.6	−4.8
14.46	1.4	0.3	−0.5	−6.2

EXPERIMENT 4

In order to determine whether or not grinding a sample made any difference in the values obtained, a large number of samples were run, both before and after coarse grinding. Table 4 shows the results. Grinding permitted the use of a smaller sample but otherwise had little effect.

TABLE 4—*Values of $T_d - T_w$ obtained with whole versus coarsely ground grain are shown for wheat, dent corn and white beans. Saturated sodium chloride solution was used on the wet bulb*

Wheat			Yellow dent corn			White beans		
Moisture percent	Whole Td - Tw	Ground Td - Tw	Moisture percent	Whole Td - Tw	Ground Td - Tw	Moisture percent	Whole Td - Tw	Ground Td - Tw
9.8	4.8	4.6	10.8	3.8	3.9	12.3	1.8	1.9
10.5	3.5	3.7	13.4	1.1	1.4	15.0	0.7	0.7
11.1	2.9	3.1	14.1	0.8	0.8	15.7	0.5	0.5
11.8	2.1	2.3	14.7	0.4	0.4	17.2	0.3	0.3
12.5	1.5	1.6	18.3	−1.5	−1.5	18.2	0.5	0.5
13.2	1.2	1.4	19.5	−1.7	−1.7			
			22.4	−2.4	−2.4			

EXPERIMENT 5

It was the intention, in previous experiments, to have the individual samples reasonably uniform and to accomplish that end, they were stored for several days before testing in closed flasks. In this experiment, five lots of wheat were used, ranging from 9.03 to 14.46 percent moisture, and samples were made by mixing, in equal amounts of wheat from every possible pair of samples. Table 5 shows the results. In every case, the temperature value obtained is intermediate between the values of the two components.

TABLE 5—*Five lots of wheat and five different moisture contents were prepared. Every possible mixture of these lots, in two equal parts was made and the $T_d - T_w$ determined at once. The values are given below. Sodium chloride solution on the wet bulb*

Sample number	1 Td - Tw	2 Td - Tw	3 Td - Tw	4 Td - Tw	5 Td - Tw
1	5.8*	4.8	3.5	2.9	2.1
2	4.8	3.8*	3.0	2.1	1.5
3	3.5	3.0	2.4*	1.8	1.2
4	2.9	2.1	1.8	1.2*	0.6
5	2.1	1.5	1.2	0.6	0.3*

*Td - Tw for the original samples.

EXPERIMENT 6

To determine whether very slight differences in moisture content might be detected, three samples of wheat grain were prepared by adding 0.0, 0.3 and 0.6 gram of water to 300 grams of wheat. This would give moisture differences of approximately 0.1 and 0.2 percent. These samples were repeatedly tested, with the wet and dry-bulb technique and finally the samples were analyzed by the chemists, when a total difference of 0.38 percent in moisture content was found.

The differences in wet-bulb depressions, or elevations, were from a minimum of 0.25° to a maximum of 0.6°, but the samples never varied in order. A discrepancy of this magnitude could easily occur from error in reading the dry-bulb thermometer.

EXPERIMENT 7

The previous experiments have been directly related to the common grains, wheat, oats, barley, corn and beans. In the manufacture and handling of these, and similar products, the necessity for moisture determinations frequently arises, and in many cases, variations of relatively slight magnitude are of great importance.

Sugarbeet pulp, for example, must be dried before shipping. Four samples were prepared by adding 0, 2, 4, and 6 grams of water to 100 grams of dried pulp. With sodium chloride on the wet bulb, the temperatures were read the same day as mixing, and the next day. Table 2 shows the temperature depressions, and the percentages of moisture.

Many cereal products are on the market. Their acceptability to the public is greatly influenced by their moisture content. Thus, fresh and stale crackers, crisp and tough breakfast foods may be distinguished merely by a slight change in moisture content. Table 6 indicates that these qualities are readily detected by the wet and dry-bulb technique, using appropriate solutions. Such examples might be enumerated indefinitely in the field of industry, where routine moisture determinations are necessary on dry materials that come to a moisture equilibrium with the atmosphere.

TABLE 6—*Breakfast foods and other very dry materials may be tested for moisture content by moistening the wet bulb with saturated solutions of magnesium chloride, zinc chloride or with other solutions with low aqueous vapor pressures.* $T_d - T_w$ *for materials in various conditions of dryness are shown below*

Moisture percent	Saturated solution used		Remarks
	Magnesium chloride Td - Tw	Zinc chloride Td - Tw	
4.93	1.2	−2.0	Fresh soda crackers
8.01	−1.3	—	Somewhat tough crackers
4.66	1.0	—	Fresh breakfast food
5.61	−0.6	—	Acceptable breakfast food
11.46	−4.5	—	Tough breakfast food
3.58	4.2	0.0	Very dry wheat grain

DISCUSSION

Many of these samples were retained for a period of several weeks, with repeated determinations on the same samples. The depression or elevation of the wet-bulb temperature was almost perfectly reproduced on successive days, even though the temperature of the room may have changed appreciably, and the sample become more uniform.

The size of sample is directly related to the applicability of this method. The sample will be found to have a rather definite limit in ability to absorb moisture, and maintain the relative humidity at a fixed point. For example, if a sample of wheat with 11-percent moisture is run with sodium chloride solution on the wet bulb, a depression of about 3.2° C. would be obtained. If this sample is permitted to stand for 2 or 3 minutes and the determination repeated, the cooling may amount to no more than 2°. However, if the sample is permitted to stand for 30 minutes, the original value of 3.2° is obtained, as it is on successive days. The evaporation, while very slight, is nevertheless appreciable, with large depressions in temperature. If the depressions are small, evaporation is slight, and the sample will give agreeing values even if rerun at once. Even when evaporation is sufficient to give substantial cooling, the wet bulb does not dry enough to be observable to the operator. A series of six samples or more was frequently run, without being able to detect any drying of the bulb even though it undoubtedly occurred. In the same way, when heating of the bulb as much as 6° C. occurred, as with magnesium chloride on the bulb in 14.5-percent moisture wheat, no condensation was superficially evident. As previously explained, such extreme cooling or heating of the bulb is unnecessary and is felt to be inadvisable, since an appropriate solution can be used, in which large deviations of the wet-bulb temperature will not occur.

It is obvious that a thermometer with a small bulb, and low thermal capacity, as well as a small cloth wick is desirable, particularly when samples with low absorbing capacity are used. Thermometers used in this experiment were ordinary chemical laboratory thermometers, graduated in degrees. It was necessary to use a hand reading-glass to estimate accurately to tenths of a degree. For very accurate work, special thermometers or equipment with low thermal capacity would be helpful.

It has repeatedly been shown that the moisture content at equilibrium with any given relative humidity will vary somewhat in different

lots of wheat, lumber, etc. Since the wheats vary in chemical composition, this variation is to be expected. However, since in a great many cases, we are more interested in their characteristics of taking up or losing water than we are in their actual moisture content, this increases rather than decreases the value of the test. And since spoilage seems to be far more closely related to relative humidity of the atmosphere than to the actual moisture content of the material, in many cases the test is definitely more informative in regard to storage characteristics than a moisture-content analysis can be.

THEORY

One brief example, relating to the theory of the test will be given. Three samples, A, B, C, of white beans were tested with sodium chloride on the wet bulb. They gave a heating of (A) 0.7° C., a heating of (B) 0.3° C., and a cooling of (C) 0.6° C. of the bulb. Samples A and B, therefore, seem to give a relative humidity in the closed container somewhat above the relative humidity given by saturated sodium chloride solution, and therefore moisture condenses on the bulb and heats it. Sample C gives a relative humidity slightly less than that of saturated sodium chloride solution, and consequently there is slight evaporation and cooling. Small weighed samples of these three lots of beans were placed in relative humidity chambers of 70-, 75-, and 80-percent relative humidity respectively for 2 days, and then reweighed, and the weights computed as 100 percent of the original weight. Table 7 shows the results. We would expect samples A and

TABLE 7—*White beans at the moisture contents shown were exposed for 2 days in air at relative humidities of 70%, 75% and 80%. If 100 is the original weight of the beans, the values given show the weights after exposure. Sodium chloride was used on the wet bulb*

Moisture percent	Td - Tw	Relative weights after exposure at		
		70 percent R.H.	75 percent R.H.	80 percent R.H.
15.65	0.5	99.52	100.83	102.65
17.19	0.4	97.66	99.06	100.74
18.21	0.7	96.55	98.02	99.71

B to dry out appreciably at 70-percent R.H., and sample C only slightly or perhaps not at all. At 75-percent relative humidity, we would expect less evaporation from samples A and B and absorption of water by C. At 80-percent relative humidity, we would expect

slight evaporation by sample A, and perhaps slight absorption by sample B. Sample C should absorb appreciably. All of this is precisely what occurred.

The mathematics of the vapor pressures of solutions and of adsorbed water is not appropriate to this paper. It is sufficient to say that the magnitude of the differences in wet-bulb temperatures at any given relative humidity between water and saturated sodium chloride solution increase as the temperature of the dry bulb increases. Another complication arises in the fact that grains, etc., will hold in equilibrium a somewhat higher percentage of moisture at a low than at a higher temperature at any given relative humidity. In either case, the differences are relatively small, but are sufficient so that *a more or less standard temperature for testing is recommended*, particularly for very accurate work. Generally speaking, a variation of 10° F. one way or the other on the dry bulb will give variations in the difference between wet and dry-bulb temperatures, on any sample, of little more than 0.1°, for the small depressions or elevations advised.

The amount of water required to bring a quart of air from 50 to 75-percent relative humidity is exceedingly small. Such an amount of evaporation from a 300-gram sample of wheat would change its moisture content approximately 1/1,000 of 1 percent. Similarly, the total quantity of evaporation required from a wet bulb to cool it 1 degree is very small, amounting to approximately the same quantity of water.

It is evident from the explanations above that samples wet with dew or other surface moisture will give relative humidities higher than they will after this moisture has had a chance to soak in. Correspondingly, it would perhaps be possible to prepare a grain sample by heating in an oven, on which a dry surface film would give a relative humidity lower than it would give after standing for an interval. These precautions and those previously described as to temperature should be kept in mind and observed to give accurate results with this method.

SUMMARY

A method has been described by means of which the moisture content and storage quality of dry products may be determined. The method uses two thermometers, one with a wet bulb on which is used not water but a saturated solution of a suitable chemical. The object is to use a solution from which there will be only very slight

evaporation at the relative humidity maintained by the sample in a closed container. For farm grains, a saturated solution of sodium chloride is suitable for the wet bulb since it will evaporate only at relative humidities lower than 75 percent (about 15-percent moisture in wheat). For drier materials, other solutions such as magnesium chloride may be used. For somewhat higher relative humidities, potassium chromate or barium chloride solutions are useful. In each case, the heating or the cooling of the wet bulb should be small, for greatest accuracy.

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FEEDING AND CONFINEMENT REARING EXPERIMENT WITH TURKEYS—ELEVENTH SERIES

By F. N. BARRETT, C. G. CARD and ASHLEY BERRIDGE
SECTION OF POULTRY HUSBANDRY AND LAKE CITY EXPERIMENT STATION

THIS REPORT is the eleventh of a series of studies on increasing turkey production efficiency. Confinement rearing methods are employed because they make possible a better control of the factors of production and are most exacting in their demands for perfectness of diet and general biological understanding.

These studies were started in 1935, and each year the same brooding, rearing and management methods are strictly adhered to in order to prevent, insofar as possible, the injection of environmental or management factors which in themselves might influence the results. The same strain of Standard Bronze turkeys is used each year to represent this breed and to serve also as a check group for comparing the results with turkeys of other breeding.

Earlier trials resulted in the development of several efficient mash formulas, of which mash 7 has proved to be an excellent all-purpose mash. This mash, with its later accompaniment of grain, is adequate for normal growth and excellent development of turkeys reared under confinement conditions. Since 1936, mash 7 has been included each year in combination with yellow corn as a standard check ration with which the results of other feed combinations are compared. The annual experiments, thus, have a close relationship to each other because the basic conditions and manner of presenting data are comparable.

When deemed of sufficient importance, certain of the feeding trials and trials with turkeys of different breeding are repeated for more than one year to check possible seasonal variations and the consistency of results. Turkeys of different breeding are commonly tried with more than one feed combination, or perhaps with a trial on a cobblestone yard as compared with the usual experimental turkey house.

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The importance of repeated trials and the usefulness of such data have become increasingly apparent as these studies have progressed.

GENERAL OBSERVATIONS

One may discern certain significant trends in considering the results of 119 separate feeding trials (1935-45) involving 3,052 turkeys of several types and varieties, and a number of different mash and grain combinations fed on a free-choice basis under confinement conditions. The data cover a period of 11 years during which time, as previously mentioned, special emphasis was placed on keeping management and environmental factors on a uniform basis. These observations are especially directed at factors having a bearing on turkey production efficiency.

Consistency of Repeated Trials

Repeated trials under controlled conditions have tended to reveal quite definite characteristics for each mash, each grain, or their combination, which may not be correctly indicated by a single trial. It is also of interest to note that these characteristics tend to be repeated with a reasonable consistency from year to year so that in a sense they become predictable. Thus, in 1938, a six-trial average (1935-37), which used Standard Bronze turkeys fed mash 7 with yellow corn as the grain on a free-choice basis, revealed that the turkeys consumed an average of 3.06 pounds of mash and 1.28 pounds of corn (a total of 4.34 pounds of feed) per pound of gain to 24 weeks of age. This is a mash-to-grain ratio of 70.5 to 29.5. A 10-trial average taken in 1938 gave substantially the same figures. The addition of 12 subsequent trials to the earlier figures for the present 18-trial average (1935-43) gives the remarkably close figures of 3.05 pounds of mash and 1.34 pounds of corn (4.39 pounds of total feed) a 69.5 to 30.5 mash-to-grain ratio. In 12 of these 18 trials the deviation from the average total feed consumed is not over 0.1 pound, with a maximum of 0.32 pound. Mash showed slightly greater variability in seven trials, having a deviation of not over 0.1 pound; in 16 with less than 0.38 pound, and in one instance with 0.7 pound. Although the grain part of the ration tends to fluctuate with mash variations to approximate the average total feed consumed, a difference from the average of 0.7 pound in mash consumption per pound of gain is not typical

and could result in a difference of from 2 to 3 cents per pound in production costs. These figures are based on the accumulated results with the standard check ration which is repeated each year.

Importance of Oats in the Ration

The grain studies, which were started in 1938, have proved to be a promising field for exploration. The grain trials quickly revealed the importance of whole oats in the ration for growing turkeys and the consistent tendency for this grain to bring about a substantial reduction in the amount of mash required per pound of gain and also in the cost of such gains. Standard Bronze turkeys in six trials (1940-44), with mash 7 and both corn and oats, consumed an average of only 2.16 pounds of mash per pound of gain or 0.89 pound less mash than when corn was the only grain (18-trial average, 1935-43). The total amount of grain consumed in these trials was increased only 1.09 pounds. The inclusion of oats changed the mash-to-grain ratio from 69.5:30.5 to the relatively low ratio of 46.76:57.24. This understanding of the value of oats in the ration has made possible the production of turkeys on approximately 30-percent less mash than formerly and at an expected reduction in production costs. The current work with other grains and mashes and also different grain and mash combinations suggests a number of interesting possibilities for increasing turkey production efficiency.

Factors Influencing Total Feed Per Pound of Gain

The type of turkey used seems to have a greater influence on the total pounds of feed consumed per pound of gain than any other single factor. Large-type turkeys tend to consume slightly less and small-type turkeys slightly more total feed per pound of gain to 24 weeks of age than turkeys of intermediate type. This tendency is remarkably consistent. In 28 trials, in which direct comparisons were made between turkeys of these different types, there was no exception to this trend; so, in a sense, it is predictable. The range of difference, between small and medium as well as between medium and large-type turkeys, quite typically has been from 0.2 to 0.4 pound when results were computed to 24 weeks of age. In these comparisons the Beltsville Small White variety is considered to represent the small type, Standard Bronze the medium, and Broad Breasted Bronze the large type. The protein content of the mash and the kind of grains used also seem to have some influence on total amount of feed consumed but are less consistent in this respect than the type of turkey used.

In only four instances in 119 trials did turkeys produce gains on less than 4 pounds of total feed, as an average, to 24 weeks of age. Two of these low-feed totals were in 1944 when one Standard Bronze and one Broad Breasted Bronze pen produced gains on 3.74 and 3.85 pounds of feed, respectively. Each pen was fed a growing mash of 25.44-percent protein content. For grain, the Standard Bronze pen had wheat, and the Broad Breasted Bronze, wheat and oats to 20 weeks of age. The grain was yellow corn after 20 weeks in both instances. In 1945, two Broad Breasted Bronze pens, fed growing mashes of 27.31- and 30.13-percent protein, with corn and oats to 20 weeks and corn only after that time, consumed 3.81 and 3.78 pounds of feed per pound of gain. In each of those years, these low-total-feed pens were the lowest in cost.

Gains have been made on less than 4.2 pounds of feed by eight additional pens, and all of these birds were on growing mashes ranging from 25- to 30.13-percent protein. Four of these pens received only yellow corn as grain; two pens had corn and oats; and two pens were provided with wheat, oats, and corn. With mashes below 25-percent protein, the lowest amount of feed consumed was 4.2 pounds with a pen of Standard Bronze turkeys fed a 23-percent growing mash and corn, in 1936.

Desirability of Low-Mash Consumption Per Pound of Gain

Low-mash consumption is usually associated with low feed cost per pound of gain. The amount of mash which turkeys will choose to consume is strongly influenced by both the protein content of the mash and the kind of grain fed, and to a less degree, by the type of turkey used. The use of high-protein growing mashes (above 25 percent) and the inclusion of oats as one of the grains are the two most prominent contributors to low-mash consumption.

In the 119 trials considered, the amount of mash consumed per pound of gain ranged from 3.91 to 1.61 pounds. In only 13 trials did turkeys consume less than 2 pounds of mash per pound of gain, as an average, to 24 weeks of age. In 11 of these instances the protein content of the mash exceeded 25 percent, and in only two trials was it below this percentage. Oats were one of the grains in all instances.

In 18 trials in which Standard Bronze turkeys were given mash 7 (27-percent protein) and only corn as the grain, the turkeys consumed an average of 3.05 pounds of the mash. When oats were also

included with the foregoing combination in six additional trials, the turkeys consumed an average of only 2.16 pounds of mash. In 15 trials in which Standard Bronze turkeys were given lower protein growing mashes, ranging from 22- to 24.9-percent protein content, and only corn as the grain, the turkeys consumed an average of 3.42 pounds of the mash per pound of gain. When oats were also included in five additional trials, the average amount of mash consumed was reduced to 2.4 pounds. The inclusion of oats, in these instances, resulted in a reduction of the amount of mash consumed by approximately 30 percent, this reduction being 29.8 and 29.2 percent, respectively. Thus, while the higher protein growing mashes characteristically produce gains with a lower mash consumption than mashes of lower protein content, the percentage reduction in mash consumption resulting from the inclusion of oats is approximately the same in each case.

Desirable Mash-to-Grain Ratio

In considering the efficiency of a given feed combination or of a certain type of turkey, the percentage of the total feed consumed in the form of mash and of grain also should be noted. Because the cost of grain is usually not over 60 to 70 percent of the mash cost, it is obvious that a combination of factors that would result in the consumption of a relatively low percentage of the total feed as mash and a relatively high percentage as grain would be desirable, providing the total amount of feed consumed is not materially increased. It is commonly observed that when the amount of mash per pound of gain is reduced, the amount of grain consumed tends to increase slightly more than the mash reduction. This usually results in a slight rise in the total feed consumed. The final result, however, is that the cost of gain tends to be lowered. The two most important factors that contribute to a relatively low mash percentage are the inclusion of oats as one of the grains, with either corn or wheat, and the use of mashes of relatively high-protein content.

In 119 trials (1935-45) with several types of turkeys and with various mash and grain combinations under a free-choice system of feeding, the percentage of the total feed consumed in the form of mash ranged from a high of 84.3 to a low of 30.4 percent. In the first instance, the turkeys consumed only 15.7 percent of their total feed in the form of grain, and in the latter instance 69.6 percent grain. In 39 of these trials in which Standard Bronze turkeys were fed only corn as the grain but with several different mashes, the turkeys consumed

3.23 pounds (72.72 percent) of mash, 1.21 pounds (17.28 percent) of grain and 4.44 pounds of total feed, as an average, per pound of gain to 24 weeks of age. With 22 additional trials (1938-45) under similar conditions but with whole oats included with the corn for the grain part of the ration, the turkeys consumed only 2.13 pounds of mash (46.60 percent) and 2.44 pounds (53.40 percent) of grain and 4.57 pounds of total feed per pound of gain. In other words, with the inclusion of oats and with mashes of possibly slightly higher protein content, it was possible to utilize 1.23 pounds of the cheaper grain to replace 1.10 pounds of the more expensive mash for each pound of gain produced. This ability to replace a substantial part of the more costly mash with cheaper grain has proved an important means for the lowering of feeding costs.

In only six instances, in these trials, were turkeys reared to 24 weeks of age with mash constituting less than 40 percent of their total feed. In those cases, the proportion of mash consumed ranged from 30.4 to 38.4 percent. All received oats, with either corn or wheat, or with both corn or wheat, as whole grain. In five of the six instances the growing mash exceeded 25 percent, and with three of these the mash was above 29-percent protein content. In only one instance was the growing mash below 25 percent. The final weights of both males and females in this group were included generally in the heavier 30-percent for the particular year. In four of the six instances, the cost per pound of gain was the lowest for the particular breed and year and was associated with mashes of the higher protein levels. The highest cost for this group was with the low-protein growing mash having a protein content of 22.75 percent, and this ranked sixth in cost in seven comparable trials for the particular year.

Thus it seems that the percentage of the total feed which turkeys will consume in the form of mash tends to be definitely and materially reduced by the inclusion of whole oats as one of the grains and also by the use of growing mashes of relatively high protein content.

Factors Influencing Final Weights

Relatively heavy final weights are desirable because they are usually associated with rapid and economical gains and superior market quality. The protein content of the growing mash seems to have a greater influence, both on the rate of growth and the final weight than the kind of grain fed. Growing mashes of relatively high

protein content (26- to 32-percent) tend to result in heavier final weights, and usually at lower cost per pound of gain, than mashes of lower (19- to 25-percent) protein levels.

In only 20 instances in 79 trials (1935-45) with Standard Bronze turkeys did the average weight of males at 24 weeks of age exceed 19 pounds. The growing mashes in all of these instances were above 26-percent protein content and ranged to a high of 31 percent. In no trial to date has this variety and strain of turkey produced an average male weight above 19 pounds at 24 weeks of age on growing mashes of less than 26-percent protein content. In only 19 instances in these 79 trials has the average weight of female turkeys at 24 weeks of age been above 13 pounds. In 16 of these 19 trials the protein content of the growing mash was above 26 percent, and in only three instances was the protein content below this figure. The grains used in these trials included corn, corn and oats, and a four-grain offering of corn, wheat, oats, and barley. All of these grains or grain combinations gave excellent results as to final weights when fed with growing mashes of relatively high protein content. Birds which received the corn and oats and the four-grain offering consumed an average of 54.7 and 54.5 percent, respectively, of their total feed in the form of grain; while those which received only corn consumed an average of only 31.5 percent of their total feed as grain.

In eight trials (1940-45), using a 27-percent growing mash and in which direct comparisons were made between corn and oats and corn as the only grain, the average weight of males receiving corn and oats was 0.88 pound heavier and females 0.47 pound heavier than for turkeys receiving corn as a single grain.

Birds in the feeding trials which resulted in relatively heavy final weights also showed a remarkable consistency for being included among the lowest in cost per pound of gain for the particular variety and year.

OBJECTIVES OF THE 1945 TRIALS

The 1945 trials included a continuation of studies with turkeys of different types on certain mash and grain combinations to obtain additional data. As already stated, Broad Breasted Bronze turkeys were used to represent the large type, Standard Bronze the intermediate, and Beltsville Small White for the small type. Previous trials indicated that each type of turkey had its own peculiar feeding characteristics

as well as growth characteristic. An example of certain of these type differences is noted in considering 18 separate trials (1939-44) in which small-type turkeys were fed several different mash and grain rations in a free-choice manner in direct comparison with turkeys of the Standard Bronze variety. In every instance in those 18 trials, the small-type turkey consumed slightly more mash and, in 16 of the 18 trials, slightly more total feed per pound of gain than the Standard Bronze. In the 1945 trials, turkeys of the three varieties stated above were fed growing mashes of three different protein levels. Corn and oats were compared with corn only with two different mashes.

Cost and rearing studies were continued with Broad Breasted Bronze, Standard Bronze, and Beltsville Small White turkeys. These three varieties were used with different mash and grain combinations and also in cobblestone yard trials.

Observations were continued on the practicability of using a permanent turkey house and also as to the use of a cobblestone yard for the rearing of market turkeys and to control losses. The data for the three cobblestone yard pens are presented as pens 11, 12, and 13. The mashes used and the feeding plan are given in tables 1 and 1A, respectively. The tables included in this report present the data for the 1945 trials.

TABLE 1—*Rations*

Mash number	7	13
Protein content of mash (percent)	27.31	30.13
Ground yellow corn	10	6
Ground oats	15	15
Wheat bran	10	10
Wheat flour middlings	10	—
Meat scrap	14	12
Fish meal	—	8.5
Dried milk	10	10
Soybean oil meal	22	25
Alfalfa meal (17% dehydrated)	5	10
Calcium carbonate	1	2
Salt	1	1
*Cod liver oil	2	.5
Total	100	100
Manganese sulfate added per ton	8 ounces	8 ounces

*Cod liver oil of 85 vitamin D units was used in ration 7, while a feeding oil of approximately 400 D units was used in ration 13. These feeding oils were discontinued at about the sixteenth week.

TABLE 1A—*Feeding plan**

Pen	Breeding	No. of birds	Hatching date	Mash		Grain	
				0 to 8 weeks	8 to 26 weeks	8 to 20 weeks	20 to 26 weeks
1	Standard Bronze	25	April 14	7	7	corn	corn
2	Standard Bronze	25	April 14	7	7	corn oats	corn
3	Beltsville Small White	25	April 14	7	7	corn oats	corn
4	Broad Breasted Bronze	25	April 14	7	7	corn oats	corn
5	Standard Bronze	25	April 28	7	13	corn	corn
6	Standard Bronze	25	April 28	7	13	corn oats	corn
7	Beltsville Small White	25	April 28	7	13	corn oats	corn
8	Broad Breasted Bronze	25	April 28	7	13	corn oats	corn
*9	Beltsville Small White	25	May 26	7	X**	corn oats	corn
*10	Broad Breasted Bronze	25	May 26	7	X**	corn oats	corn
11	Standard Bronze	25	May 12	7	13	corn oats	corn
12	Beltsville Small White	25	May 12	7	13	corn oats	corn
13	Broad Breasted Bronze	25	May 12	7	13	corn oats	corn

*Mash was available at all times from the first day to the end of the trials with all pens. Grain as indicated above was added to all diets at the end of the eighth week and was fed in a free-choice manner from then on to the finish. Oats, when included, were gradually reduced after the eighteenth week and were discontinued at the end of the twentieth week.

**Mash X is a commercial growing mash of 21.0-percent protein content which is used rather extensively in this area. This mash is included for comparison with open-formula growing mashes of higher protein content

TABLE 2—*Proportion of mash and grain consumed** *(total mash and grain consumed = 100)*

Pen	0–4 Weeks		5–8 Weeks		9–12 Weeks		13–16 Weeks		17–20 Weeks		21–24 Weeks		25–26 Weeks	
	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain
1	100	0.0	100	0.0	99.5	0.5	98.1	1.9	82.2	17.8	44.0	56.0	31.6	68.4
2	100	0.0	100	0.0	99.6	0.4	57.8	42.2	48.4	51.6	38.5	61.5	24.8	75.2
3	100	0.0	100	0.0	92.0	8.0	70.3	29.7	55.6	44.4	51.6	48.4	31.0	69.0
4	100	0.0	100	0.0	86.4	13.6	72.3	27.7	61.8	38.2	54.4	45.6	38.2	61.8
5	100	0.0	100	0.0	99.9	0.1	98.3	1.7	74.0	26.0	45.4	54.6	20.2	79.8
6	100	0.0	100	0.0	59.1	40.9	47.3	52.7	50.8	49.2	32.1	67.9	14.1	85.9
7	100	0.0	100	0.0	86.8	13.2	63.5	36.5	56.7	43.3	44.3	55.7	26.0	74.0
8	100	0.0	100	0.0	70.5	29.5	63.3	36.7	54.2	45.8	45.0	55.0	33.3	66.7
9	100	0.0	100	0.0	97.6	2.4	80.0	20.0	51.2	48.8	37.1	62.9	39.2	60.8
10	100	0.0	100	0.0	100.0	0.0	73.0	27.0	56.5	43.5	44.3	55.7	13.3	86.7
11	100	0.0	100	0.0	42.5	57.5	40.2	59.8	38.4	61.6	26.3	73.7	16.4	83.6
12	100	0.0	100	0.0	62.2	37.8	50.6	49.4	53.5	46.5	40.6	59.4	21.9	78.1
13	100	0.0	100	0.0	64.2	35.8	55.7	44.3	50.5	49.5	41.0	59.0	24.4	75.6

*Mash in hoppers at all times. Grain in hoppers after the eighth week.

Experimental Pens at East Lansing

The poults used in these trials were hatched from eggs produced by the breeding flocks at the Lake City Experiment Station. The hatching dates for the different pens are given in Table 1A. The newly hatched poults, in lots of about 50, were placed in small pens and provided with shavings for litter and a small brooder. Only mash 7 in hoppers and water in vacuum fountains were given for the first week.

At the end of the first week, the poults were weighed and sorted into experimental lots of 25 each. Each lot was provided with an indoor floor pen, 4½ feet wide and 10 feet long, with an electric hover. Perches were added when the hovers were no longer required.

Because of restricted space in the laboratory, it was necessary to remove each group to quarters in a laying house when they were 4 weeks of age. With each lot, it was necessary to keep the poults under the conditions described until their age and the weather conditions made it possible to transfer them to the large, open-front house at Lake City. This was between 7 and 8 weeks of age for each group.

The Lake City Turkey House

At the Lake City Station, each lot of 25 turkeys (with the exception of yard pens 11, 12, and 13) was confined to a pen 10 feet wide and 24 feet long in the open-front turkey house. This building, which is 100 feet long, is constructed of rough lumber and poles. The house is divided into pens with wire and wood partitions. At the end and back walls are hinged panels that may be opened for ventilation in summer. At the rear of each pen are perches and a dropping board. The floors are of concrete, and chopped straw is used as litter.

The Cobblestone Turkey Yard

Cobblestone yards have provided a relatively simple method of yarding turkeys for the control of Blackhead. The first of these yards was constructed at the Lake City Station in 1936, and others have been added since this time. These are permanent yards, and the ones used primarily for experimental work are approximately 40 by 80 feet in size. Each yard is provided with an inexpensive shelter with roosting quarters. The essential feature of the yard is that the ground is covered to a depth of 6 to 8 inches with field stones that vary in size from about 3 to 6 inches in diameter so that the turkeys do not come

in contact with the soil. Each rain washes off the droppings, and the yard looks clean, even in the summer months when the rains are less frequent. If, in the course of time, the yards need renovating, the stones may be loosened with a spring-tooth harrow and more stones added as needed.

Experimental pens 11, 12, and 13 are reared on these cobblestone yards.

Feeding Plan

A free-choice feeding of corn and oats was used with all pens, except pens 1 and 5 which received only corn as grain, and this was hopper-fed as with the two-grain choice. Grain feeding was started with all pens when the poults were 8 weeks of age. With all corn and oat pens, the oats were gradually reduced in the amount offered after the eighteenth week, and oats were entirely discontinued after the twentieth week, leaving corn as the only grain from then on to the finish. The corn and oats were hopper-fed in an equal and free-choice manner to the 11 pens receiving this two-grain offering. The variety of turkey used as well as the ration is shown in Table 1A which outlines the feeding plan. The birds in house pens 5, 6, 7, and 8 and cobblestone yard pens 11, 12, and 13 received mash 7 until the end of the eighth week, at which time they were changed to mash 13 until the trials were completed. Mash 13 is a concentrate mash, with a protein content of approximately 30 percent, and mashes of this type are expected to bring about the consumption of relatively large amounts of grain. Beltsville and Broad Breasted Bronze turkeys, in pens 9 and 10 respectively, received mash 7 until the end of the eighth week when they were changed to mash X for the remainder of the trials. Mash X is a low-protein commercial mash of approximately 21-percent protein content which is used rather extensively in this region. The turkeys in pens 1, 2, 3, and 4 received mash 7, which has a protein content of approximately 27 percent, for the entire period of these trials.

Rearing and cost studies with Standard Bronze turkeys were conducted with birds in pens 1, 2, 5, 6, and 11; with Beltsville Small White turkeys in pens 3, 7, 9, and 12; and with Broad Breasted Bronze in pens 4, 8, 10, and 13.

Standard Bronze, Beltsville, and Broad Breasted Bronze are comparable under different conditions in pens 2, 3, and 4; 6, 7, and 8; 11, 12, and 13; and also are Beltsville and Broad Breasted Bronze in pens 9 and 10, as the management and diet were the same in each group-

ing. A comparison of housed turkeys and yarded birds on the same ration may be made with Standard Bronze in pens 6 and 11, Beltsville turkeys in pens 7 and 12, and Broad Breasted Bronze in pens 8 and 13, respectively. The results under different conditions, with the three turkey varieties considered, may be observed by examination of the several tables which accompany this report.

CURRENT OBSERVATIONS

Type and Sex Differences with Respect to Maturity

It is commonly known that female turkeys tend to mature at an earlier date than male turkeys, but information is quite limited on differences as to time of maturity that may exist between turkeys of various types. The data of the current trials afford an opportunity to make comparisons between turkeys of small, intermediate, and large types because the diet and rearing methods are comparable in each grouping.

In these trials, at 16 weeks of age, male turkeys had attained an average of 50.2 percent of their 26-week weight while females averaged 60.0 percent of their final weights. Beltsville turkeys were slightly above (males 51.4 percent, females 63.6 percent), while Broad Breasted Bronze were slightly below these figures (males 48.7 percent, females 57.2 percent). Standard Bronze turkeys approximated the average for the three varieties considered.

In the growth of turkeys there is a period in which they attain their greatest rate of gain, and the age at which this occurs differs with turkeys of different type and sex. The period in which Beltsville and Standard Bronze females made their greatest gains in these trials was, in all instances, prior to the 17th week and was about equally divided between the 9- to 12- and the 13- to 16-week periods. Beltsville hens tended to produce their greatest gains slightly earlier than the Standard Bronze, while Broad Breasted Bronze females produced their greatest gains about 4 weeks later than the Beltsville females. In all of these trials, the Beltsville males made their most rapid gains prior to 24 weeks of age, while 40 percent of the Standard Bronze and 75 percent of the Broad Breasted Bronze males had their most rapid rate of growth between the 24th and 26th week. These observations indicate a difference of nearly 4 weeks in the age of arrival at the peak of growth acceleration between male and female turkeys within a given variety, and also suggest a similar difference between these sexes in the

age at which they arrive at a corresponding stage of marketable maturity.

As turkeys approach maturity their rate of gain tends to diminish. In this connection, certain evidences are observed as to differences in time of maturity of turkeys of different type and sex when comparisons are made between the rate of gain during the 24- to 26-week period and the rate of that period in which the particular variety and sex made its most rapid gains. It is of interest to note that these comparisons are consistent with the other observations as to differences in time of maturity between types and sexes. During the 24- to 26-week period, the average rate of gain with males of the Beltsville, Standard Bronze, and Broad Breasted Bronze varieties was 80, 91, and 98 percent and with females 45, 64, and 67 percent, respectively, of the rate of gain in that period in which these varieties and sexes made their greatest rate of gain.

These and other observations suggest that there is a difference of as much as 3 or 4 weeks between Beltsville and Broad Breasted Bronze turkeys of either sex, in arriving at a given point in the final stages of maturity.

Feed Consumed Per Pound of Gain

In computing the efficiency of a diet it is advisable to consider the proportion of mash to grain, as well as the total quantity of these ingredients, required to produce a pound of gain (Table 3). The

TABLE 3—*Pounds of feed consumed per pound of gain (average to 24 weeks of age)*

Feed	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mash	3.41	2.54	3.14	2.66	3.57	2.20	3.31	2.50	3.18	2.96	1.84	2.75	2.16
Corn	.81	.88	.68	.66	1.03	1.02	.92	.82	1.10	.92	1.68	1.36	1.11
Oats	—	.76	.77	.49	—	1.08	.95	.77	.52	.53	1.01	.90	.60
	4.22	4.18	4.59	3.81	4.60	4.30	5.18	4.09	4.80	4.41	4.53	5.01	3.78

tendency for whole oats to result in a material reduction in the amount of mash consumed may be noted in comparing the results with Standard Bronze turkeys in pens 1 and 2 and also pens 5 and 6. Pens 2 and 6 receiving both oats and corn consumed an average of 32 percent less mash than pens 1 and 5 which had only corn as grain. The

proportion of feed by periods and the average pounds of mash and grain consumed per pound of gain are given in tables 2 and 3, respectively. The pounds of feed required to produce a pound of gain is distributed by periods in Table 3A.

TABLE 3A—*Pounds of feed consumed per pound of gain (distributed by periods)*

Pen	1–4 Weeks		5–8 Weeks		9–12 Weeks		13–16 Weeks		17–20 Weeks		21–24 Weeks		25–26 Weeks	
	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain	Mash	Grain
1.....	2.14	0.0	2.43	0.0	3.52	0.02	4.26	0.08	4.23	0.92	2.63	3.35	2.71	5.88
2.....	1.99	0.0	2.37	0.0	3.42	0.01	2.21	1.61	2.56	2.73	2.47	3.94	1.38	4.19
3.....	2.42	0.0	3.16	0.0	3.45	0.30	2.96	1.25	3.42	2.73	3.31	3.10	2.05	4.56
4.....	2 12	0.0	2.70	0.0	2.57	0.40	2.58	0.99	3.03	1.87	2.89	2.42	2.55	4.12
5.....	2.04	0.0	2.75	0.0	3.59	0.01	4.96	0.09	3.61	1.27	3.22	3.88	1.82	7.19
6.....	2.32	0.0	2.90	0.0	1.84	1.28	2.18	2.43	2.60	2.52	1.99	4.21	1.00	6.10
7.....	2.33	0.0	3.01	0.0	3.38	0.51	3.53	2.02	3.93	2.99	3.18	2.78	2.50	7.14
8.....	2.63	0.0	2.67	0.0	2.17	0.91	2.63	1.52	2.78	2.35	2.57	3.14	2.02	4.06
9.....	2.53	0.0	3.13	0.0	4.02	0.10	4.06	1.01	2.69	2.56	2.53	4.29	3.54	5.49
10.....	2.82	0.0	2.70	0.0	3.70	0.00	3.21	1.19	2.78	2.14	2.67	3.36	0.60	3.92
11.....	2.25	0.0	2.52	0.0	1.53	2.08	1.81	2.70	2.07	3.33	1.60	4.49	1.17	5.96
12.....	2.45	0.0	3.03	0.0	2.30	1.40	2.89	2.82	3.42	2.98	2.50	3.67	2.90	10.36
13.....	2.17	0.0	2.63	0.0	1.96	1.09	2.24	1.78	2.13	2.09	1.98	2.85	1.27	3.95

Average Cost of Producing a Pound of Gain

In determining the merits of any ration, the cost of producing a unit of gain is one of the factors to be considered. This information is given for each pen in Table 4. Consideration should also be given to the normal development of the birds, the growth rate, the character of the finished product, and any other advantage or disadvantage of a particular ration before final conclusions are made. A ration that produces the cheapest gains in one year may not be so economical in another year because of changing prices. Thus, in 1944 the price paid for corn was 70 percent of the cost of mash while wheat was obtainable at 55 percent of the mash cost. Under such conditions, rations using relatively large amounts of wheat may produce cheaper gains than if the situation is reversed. In the 1945 trials, the inclusion of oats resulted in a substantial reduction in cost of gains even though the price paid for oats was slightly higher than that of corn on a pound basis.

TABLE 4—*Feed cost per pound of gain (average to 24 weeks of age)*

Feed	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Mash	$0.140	$0.104	$0.129	$0.109	$0.154	$0.095	$0.142	$0.108	$0.128	$0.119	$0.079	$0.118	$0.091
Corn	0.020	0.022	0.017	0.017	0.026	0.026	0.023	0.020	0.028	0.023	0.042	0.034	0.025
Oats	—	0.020	0.020	0.013	—	0.028	0.025	0.020	0.014	0.014	0.026	0.023	0.017
Mash and grain total	$0.160	$0.146	$0.166	$0.139	$0.181	$0.149	$0.190	$0.148	$0.170	$0.156	$0.147	$0.175	$0.133

Feed Prices

The average prices paid per 100 pounds for the different mashes and grains in 1945 were: Mash 7, $4.10; mash 13, $4.35; mash X, $4.00; whole corn, $2.50 and oats, $2.60. Since 1940, the average price paid for corn and oats averaged 62.8 percent of the price paid for mash 7. The price paid for corn varied from 57 to 69 percent and oats 58 to 68 percent of the mash 7 price in different years. In the 1945 trials the average price paid for corn was 61 percent and for oats 63 percent, of the price paid for the mash. This was regarded as a reasonable relationship under our conditions.

Growth Rates

The rate of growth of the three varieties of turkeys used and the results with different feed combinations may be noted in Table 5. This

TABLE 5—*Growth of turkeys (average weight in pounds)*

Pen	4 Weeks		8 Weeks		12 Weeks		16 Weeks		20 Weeks		24 Weeks		26 Weeks	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1	0.94	0.87	2.6	2.3	5.6	4.6	9.0	7.1	12.8	9.3	16.1	11.2	17.8	12.0
2	0.98	0.90	2.7	2.2	5.9	4.6	10.2	7.5	13.9	9.3	17.1	10.9	19.5	12.2
3	0.91	0.83	2.5	2.0	5.2	3.9	8.6	6.2	11.6	7.5	14.6	8.7	16.2	9.4
4	1.19	1.02	3.5	2.9	7.6	5.9	12.7	9.3	16.9	12.0	22.0	14.3	24.4	15.8
5	0.96	0.89	2.7	2.4	5.7	4.9	8.9	7.4	12.8	9.6	16.4	11.7	17.7	12.5
6	0.90	0.86	2.6	2.3	6.1	5.0	10.1	7.4	13.8	9.5	17.5	11.6	19.5	12.4
7	0.87	0.76	2.3	1.9	5.1	3.9	8.1	5.7	11.2	7.1	13.9	8.6	15.3	8.9
8	1.10	1.01	3.3	2.8	7.5	6.3	12.1	9.7	16.3	12.3	21.1	15.0	24.0	16.1
9	0.85	0.77	2.5	2.1	5.0	4.0	8.0	5.9	11.8	7.8	14.8	9.2	16.4	9.7
10	0.93	0.81	3.1	2.6	6.5	5.3	11.0	8.4	16.1	11.7	21.0	14.3	23.8	15.3
11	0.93	0.79	2.8	2.2	6.1	4.5	10.0	7.2	13.9	9.6	18.3	11.7	20.4	12.5
12	0.86	0.79	2.4	1.9	5.0	3.7	7.7	5.4	11.1	6.8	14.7	8.3	15.7	8.5
13	1.18	1.06	3.4	2.9	7.5	5.7	12.0	8.5	17.1	11.3	22.8	14.2	25.9	15.5

table gives the average weight of both male and female turkeys at the end of each 4-week period to 24 weeks of age, and the results to 26 weeks of age is also included. The final weight summary is given in Table 6.

TABLE 6—*Final weights of turkeys in pounds at 24 weeks of age*

	Pen												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Birds started	25	25	25	25	25	25	25	25	25	25	25	25	25
Surviving birds	24	25	25	24	24	24	25	24	24	22	25	24	24
Total weight (lb.)	308 0	359 1	300 3	459 2	341 4	316 4	272 9	420 2	288 2	394 9	404 8	295 7	469.6
Number of males	8	14	14	15	13	8	11	10	12	12	17	15	15
(*pounds*)													
Heaviest male	18.2	19.1	17.2	29.3	18.9	19.8	17.4	24.5	16.2	23.6	19.6	16.6	25.9
Lightest male	12 4	14 5	13 1	17 9	14 2	16 2	11 7	14 0	12 9	15 8	12 9	12 5	19 8
Average weight	16.1	17.1	14.6	22.0	16.4	17.5	13.9	21.1	14.8	21.0	18.3	14.7	22.8
No. of females	16	11	11	9	11	16	14	14	12	10	8	9	9
(*pounds*)													
Heaviest female	12 3	12 3	9 8	15 5	12 6	13 4	9 4	17 8	9 8	15 4	12 8	8 8	16.5
Lightest female	9.5	9.8	7.7	13.2	10.4	10.6	8.0	13.1	8.7	12.2	10.2	7.8	13.2
Average weight	11.2	10.9	8.7	14.3	11.7	11.6	8.6	15.0	9.2	14.3	11.7	8.3	14.2

SUMMARY

Under a free-choice system of feeding used in these continuing trials turkeys have tended to develop a characteristic feeding pattern for each mash, each grain and each mash and grain combination, which they have followed with remarkable consistency from year to year.

The type of turkey used seems to have a greater influence on the total amount of feed that will be consumed per pound of gain than any other single factor.

Small-type turkeys have tended to consume slightly more and large-type turkeys slightly less total feed per pound of gain than turkeys of intermediate type; this tendency, also, has been remarkably consistent.

The range of difference between small and medium and also between medium and large-type turkeys, in amount of feed consumed per pound of gain, characteristically has been from 0.2 to 0.4 pound, when results were computed to 24 weeks of age.

When mashes of relatively high-protein content (above 25 percent) were fed, turkeys have tended to consume fewer pounds of mash and a higher percentage of their total feed in the form of grain, and usually have made heavier final weights, generally at lower cost, than when mashes of lower protein content were used.

In repeated trials, when whole oats were included with corn, for the grain part of the diet, turkeys have consumed approximately 30 percent less mash, regardless of the protein content of the mash.

In the 1945 trials, female turkeys tended to arrive at the peak of growth acceleration approximately 4 weeks earlier than males of the same variety. Beltsville Small White turkeys, of either sex, were 3 to 4 weeks earlier than Broad Breasted Bronze in arriving at that period in which a variety attains its greatest rate of growth. Similar differences were observed as to time of arrival at a corresponding stage of market maturity.

A TEST OF HUNTING AS COTTONTAIL CONTROL

By M. D. PIRNIE

CONSERVATION INSTITUTE AND SECTION OF ZOOLOGY

THE COTTONTAIL RABBIT* is widely distributed and quite abundant on many Michigan farms. It is an important game species, and the annual take by hunters has been estimated by Hickie (4) to exceed 2,000,000 animals. Also, these rabbits are sometimes very destructive to ornamental shrubbery, young orchards and forest seedlings, and to garden crops. The game law provides for the issuance of control permits; but one often hears it argued that open-season shooting will give all of the necessary control.

In southern Michigan the open season has extended from October 15 only to the end of December, but in more northern counties of the lower peninsula hunting may continue to the end of January. There is a popular belief that rabbits cannot stand a longer season in the southern zone because of the greater hunting pressure in thickly settled regions. Actually there is little proof on this subject. In 1931, Aldo Leopold (5), writing of the lakes states area, said, "There is no unanimity of opinion, for instance, whether shooting greatly affects rabbit abundance." Even now, this statement holds.

While serving Michigan State College as director of its W. K. Kellogg Bird Sanctuary from 1931 to 1948, the writer had an excellent opportunity for a test of cottontail control by shooting. This College property is located 12 miles from Battle Creek and is in a region of cottontail abundance. Together, the Kellogg farm and bird sanctuary offered nearly 600 acres of assorted rabbit cover—farm fields, swales, woodlots, brush patches, and conifer plantations—where the hunting could be controlled and accurate kill records obtained. Here was a nearly ideal place to study cottontail survival under heavy, regular shooting. Several graduate students helped in many ways, notably D. L. Allen in 1936 and 1937. Many thanks are due C. M. McCrary,

Sylvilagus floridanus mearnsii Allen

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superintendent of the Kellogg Station,* for his cooperation which made possible this long-time test.

Although the rabbit season opened on October 15, the test shooting was postponed until December and generally restricted to that month for the following reasons: a) to avoid disturbing the wild ducks and geese using the Kellogg Bird Sanctuary, b) because rabbits are well-grown and usually fat in December, and c) hunting is more effective with snow on the ground. (Present knowledge indicates another reason in favor of late rabbit hunting: that risk of catching tularemia from handling rabbits is very much less in December than in October.)

For 16 consecutive Decembers, 1932 through 1947, the shooting was kept as uniformly heavy as possible, taking into account the great variation in snowfall and other weather conditions. No rabbit refuges were set aside and no attention was given to saving breeding stock; for this was to be a test of how well the cottontail could "take it," and it was to be a test of heavy and regular shooting as a possible control measure.

Figure 1 shows the number of cottontails bagged each December from 1932 through 1947 when the test ended. The total recorded kill was 1,649 rabbits, an average of 103 for each of the 16 years. The take varied from a low of 60 to a high of 172. Since the shooting took place on less than 500 acres, the average yield was one rabbit from about

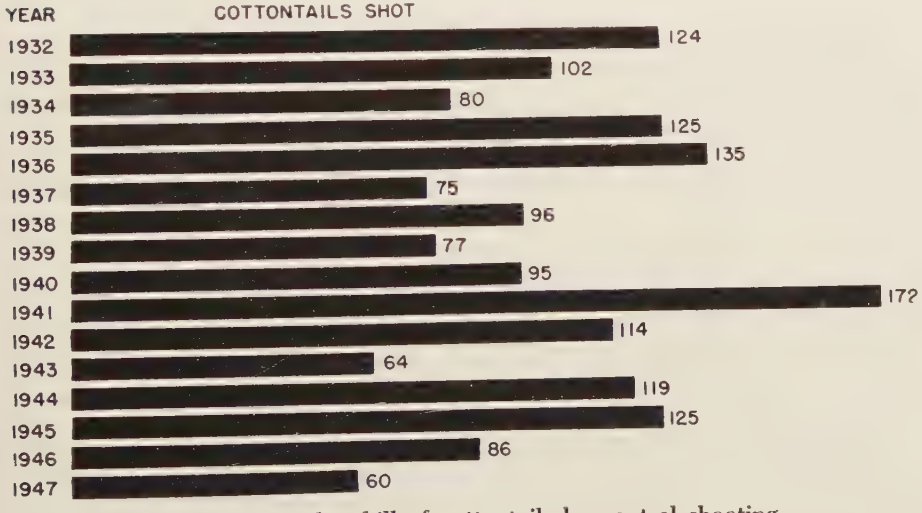

Fig. 1. December kill of cottontails by control shooting.

*In 1948 the W. K. Kellogg Farm, Forest, and Bird Sanctuary—all three projects near Gull Lake in northeast Kalamazoo County—were renamed the "Kellogg Station of Michigan State College."

5 acres. This is very close to the calculated yield listed by Hickie (2)—an average of 110 rabbits annually from each section of land (640 acres) in the southern counties. It seems evident that this test was conducted on well-stocked rabbit range and that the shooting removed at least as many cottontails as would have been taken by ordinary hunting.

The shooters were wildlife students and members of the farm and bird sanctuary staffs, plus a few guests. The hunts were carefully planned both for safety and for uniform coverage of the tract. Occasionally lone hunters used small-bore rifles, but the usual firearm was the shotgun. Rabbit hounds were seldom worked; but many rabbits were routed from the pines and spruces and from bittersweet tangles by the writer's springer spaniel and Chesapeake retriever, and by McCrary's Boston terrier.

The hunting was chiefly by "drives" in which from five to fifteen hunters participated. Since cottontails are not easily driven, most of the hunts were conducted in skirmish line, with the shooters spaced several rods apart. This permitted safe shooting at most rabbits jumped; but this type of hunt is no place for careless shooters or novices.

Fifty-two of these larger group hunts, or drives, yielded 907 cottontails, an average of 17.5 rabbits per hunt of about 5 hours. This figures 2.5 rabbits per hunter, or 2 hours per gun for each rabbit bagged. As many as 52 were taken in one full-day hunt. This form of control would be quite expensive, we fear, if the landowner had to buy ammunition and hire shooters. Actually, there always was a waiting list of willing helpers, but for safety and ease in directing the hunts, we preferred experienced gunners.

Smaller hunts by one to four men took a total of 742 cottontails in 174 forays. These hunters bagged a rabbit, on the average, every 1½ hours per gun, a slight advantage over the average of 2 hours required in the drives. The small hunts had a distinct advantage, for many of them took place in late afternoon, when cottontails are especially active and therefore more easily seen and shot.

Rabbit survival at the close of the shooting period was indicated by their tracks in the snow and by observing them in early morning and at dusk. We found that quite a few cottontails were enjoying the protection of culverts or living in the dens of other animals and under the field poultry houses. Our best evidence that the well-planned,

intensive shooting missed many rabbits was obtained, however, by rabbit population studies made on the test area between 1935 and 1937 by D. L. Allen, a graduate student (1, 2). Allen box-trapped and ear-tagged local cottontails between January and March 1937, and found over 50 animals present, in spite of the kill of 135 removed the previous December. His work indicated we might be shooting not over 60 percent of the rabbits present on the area when shooting began; and this could scarcely be considered effective control!

In spring we often saw five or six cottontails in sight at one time. This was more than were jumped on some of the last shoots. No matter how low the December kill had been, each spring and summer seemed to have a good breeding stock and fair numbers of baby rabbits. Abundant rabbits in summer, however, did not always mean large numbers in December. In the summer of 1947, for example, the animals were very abundant, but shooting that December was the poorest in 16 years! Shooting is by no means the only mortality factor.

During these studies, both Allen and the writer came to the conclusion that many factors other than shooting affected rabbit populations on the test area. Allen found diseases more prevalent in late winter; in one week in March 1936, the writer found three cottontails which were evident victims of disease. Predators of many kinds were present, but we found no direct relation to cottontail numbers. Rabbits showed no increase when skunks almost completely disappeared from the area; and our best harvest of cottontails came in 1941 when red foxes were regularly present.

Regardless of what factors kept rabbits from being more abundant, the fact remains that neither shooting, diseases, nor predators prevented fairly successful recovery each year of the test. Since the surviving rabbits destroyed or damaged dozens of young beech, mountain ash, and hemlock trees which we had set out but not yet protected by wire guards, the test failed to give the sort of control sought in commercial tree nurseries and in young orchards.

If shooting is to be considered a useful means of local control of cottontails in Michigan, it seems that the open season would have to be greatly extended or special permits given to allow shooting, not only when damage is being done, but also from the end of the shooting season well into the spring. Such local attempts at control could have little effect on cottontail populations throughout the state.

Good conservation practice demands raising those crops for which the land is best adapted, whether lettuce or rabbits. Also, it is good

wildlife management to grant wildlife species no more protection than each needs in order to survive in reasonable numbers appropriate to the farm or forest areas which they occupy. Certainly we should not fear to apply control measures against an animal with the "come-back" which the cottontail has repeatedly demonstrated.

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THE RELATION BETWEEN DIFFERENT METHODS OF APPLYING PARATHION AND THE AMOUNTS DEPOSITED ON APPLE LEAVES FOR THE CONTROL OF EUROPEAN RED MITE

By A. E. MITCHELL, HERMAN KING, EILEEN K. CARR, and E. J. BENNE

SECTIONS OF HORTICULTURE, ENTOMOLOGY AND AGRICULTURAL CHEMISTRY

THERE IS CONSIDERABLE interest among fruit growers for a more rapid and efficient means of applying spray chemicals used in fruit growing. The following investigations were undertaken to evaluate, as far as possible, different methods of applying spray chemicals including concentrate sprays, wet-dusts, dry-dusts and conventional hydraulic sprays.

A variety block of approximately 110 mature apple trees located on the Michigan State College Horticultural Farm, East Lansing, was used for this study. The trees were uniform in size within varieties and heavily infested with European red mite (*Paratetranychus pilosus*, Canestrini and Fanzago) (Table 1). Parathion (O, O-diethyl O-p-nitrophenol thiophosphate), a new organic acaricide[1], was used in comparing the various methods of application. This material was

TABLE 1—*Effectiveness of various methods of applying parathion to apple trees for the control of European red mite*

Treatment*	Actual parathion applied per tree, in ounces	Average number of mites per 62.5 sq. in. of leaf area			
		Time of application	Days after application		
			4 days	11 days	21 days
Conventional spray	1.28—1.44	97	5	16	15
Concentrate spray	1.22—1.50	108	1	10	7
Wet-dust	1.20—1.44	91	1	14	8
Dry-dust	1.20—1.44	98	2	37	38
No Treatment	—	65	5	51	52

*Treatments made August 5, 1948, between 7 p.m. and 9 p.m.

[1]An acaricide is a substance or preparation which kills acarids or mites.

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selected because a quantitative procedure is now available to determine residues of it on plant tissues, and also because when properly used it has proved to be very effective for European red mite control. The treatments were made across the variety rows to insure uniformity of comparisons. Two rows of guard trees were used on each side of the dust treatments, and a single row of guard trees was used between spray treatments to avoid confusion in results because of drift.

The Bean Mist-Duster[2] with a fixed outlet was used to apply the dry-dust, wet-dust and concentrated spray materials. A Bean hydraulic sprayer with a 20-gallon capacity pump, operating at 600 pounds pressure, equipped with an 8-nozzle hand-operated broom, was used to apply the conventional spray.

Before any treatments were made the rate of discharge of material was carefully calibrated for each method of application, and this was coordinated with the rate of speed at which the machine would pass the trees to be treated. The calibration was made so as to insure the same quantity of controlling ingredient per tree per treatment. The conventional hand-sprayed treatment was used as a basis for the quantity to be applied, as it was first determined that the trees in this treatment would require 15 to 18 gallons of spray, depending upon the variety. The range was necessary because the treatments included several varieties, and some require more spray or dust than others for complete coverage because of natural tree size differences. This tree size difference was considered also in applying the treatments with the Bean Mist-Duster, in that it would take longer to pass by a large tree than a small one if the machine were moving at a uniform rate.

The treatments were made on the evening of August 5, 1948, between 7 p. m. and 9 p. m. when air conditions were ideal for any type of spray or dust application. All the trees were sprayed or dusted from opposite sides to insure complete coverage. During the following 48 hours the guard trees were sprayed carefully by hand to avoid any drift, using 1 pound of 25-percent parathion per 100 gallons of spray. This was done to eliminate any possible migration of mites from the guard trees to the treated trees.

Counts of European red mite were made on August 5, 1948, prior to the acaricide treatments and again 4, 11 and 21 days later (Table 1). Twenty-five medium-sized spur leaves, one from each spur, were col-

[2]Manufactured by the John Bean Manufacturing Company, Division of Food Machinery Corporation of Lansing, Michigan. This machine operates as a concentrate sprayer, dry-dust or wet-dust applicator. An air blast of 120 miles an hour, created by a paddle-wheel-type fan, carries the spray or dust material from the machine to the tree.

lected from each tree. The leaf samples were gathered from spurs selected at random, 5 to 7 feet above the ground level, from the inside and the perifery, entirely around the tree. Only one leaf was selected from each spur. A total of 62.5 square inches of leaf area per tree (this includes two counts per leaf) was observed for European red mite infestation (Table 1). The counts were made on a magnified field of 1.25 square inches, observing both the upper and lower surfaces of the leaves. The field for the mite count included the middle portion of the leaf blade, the midrib dividing the field into equal portions.

Samples of leaves to determine the amount of residual parathion were taken on August 7, 19 and 26, 1948, in the same manner as those used for the mite counts . The leaves from all the trees in one treatment were composited, and the leaves actually used in the analysis were selected at random from this sample. Residual parathion was removed from the leaves by extraction with benzene and evaluated photometrically by the method of Averell and Norris[3]. The results are given in Table 2.

TABLE 2—*A comparison of the quantities of residual parathion deposited on the leaves of apple trees by various methods of application and its resistance to weathering*

Treatment*	Actual parathion applied per tree, in ounces	Residual parathion in p.p.m.		
		Days after treatment		
		2 days	14 days	21 days
Conventional spray	1.28—1.44	79.1	15.2	3.2
Concentrate spray	1.22—1.50	107.6	31.2	10.9
Wet-dust	1.20—1.44	38.6	7.1	0.8
Dry-dust	1.20—1.44	8.8	0.4	3.8
No treatment	—	0	—	—

*Treatments made August 5, 1948, between 7 p.m. and 9 p.m.

A comparison of the mite counts shows little to no differences in the effectiveness of the wet-dust, concentrate spray, and conventional spray even though the residual quantity of parathion for the concentrate spray was approximately three times greater than that for the wet-dust and one-third greater than that for the conventional hydraulically applied spray. The dry-dust treatment resulted in the smallest quantity of residual parathion and was the least effective against the mites. This was probably due to the trees being dry at the time the treatments were made.

[3]Analytical Chemistry, *20:* 753, 1948.

The amounts of residual parathion (Table 2) may induce one to believe that the quantity of actual parathion, if applied in concentrate form, could be reduced to at least two-thirds of that used in this test, and still give good prolonged commercial control of European red mite. By the same reasoning, the quantity of actual parathion used in the conventional spray application could be reduced at least 50 percent.

It is of economic interest that even though approximately the same quantity of actual parathion was applied per tree per treatment (Table 1), the amount of residual parathion on the leaves was much greater for the concentrate application than for the other treatments. This was due no doubt to little or no run-off when the spray was applied in concentrate form. Also, more actual parathion was retained on the leaf surface by the wet-dust treatment than by the dry-dust treatment. It is known that less dust fungicide and insecticide are retained on dry plant surfaces than if applied when the plant is wet with dew or rain, and the trees used in this experiment were dry when the parathion applications were made. It is of interest that the European red mite infestation was not entirely eliminated by any of the treatments. The probable explanation of the reduced population of mites on the check trees 4 days after the parathion treatments is that sufficient parathion volatilized into the atmosphere surrounding the check trees to kill any mites that were present. However, newly hatching eggs quickly rebuilt the population to almost its original figure. This was to be expected as there was no residual parathion on the leaves of these trees to kill the larvae as they continued to hatch.

The results of this investigation are of interest in that they suggest the possibility of reducing the quantity of spray chemicals that may be used effectively when these chemicals are applied as a concentrate spray in place of the conventional spray, wet-dust, and dry-dust.

A SELF-LOADING AND SELF-UNLOADING WAGON FOR LONG HAY

By S. T. DEXTER
SECTION OF FARM CROPS

WHEN LABOR REQUIREMENTS in handling dry or tough long hay with a hay loader and a fork or slings, are considered and classified the following facts emerge:

1. *Cutting*—Little muscular effort, no dust, no discomfort.
2. *Raking*—Little muscular effort, little dust, no discomfort.
3. *Driving tractor on loader*—No effort, or discomfort; little dust.
4. *Working in front of the hay loader*—Loading the hay on the wagon is very heavy muscular work, even for a young man; two men required for large racks; frequent stoppages and delays under even the best circumstances, because of handling the hay. Considerable dust, much discomfort. Not a popular job for hired labor.
5. *Driving to the barn*—No effort, dust or discomfort.
6. *Handling the grapple forks, etc., in unloading*—Considerable muscular effort, dust and discomfort.
7. *Mowing the hay away in the barn*—Great muscular effort; very hot work; dusty; much discomfort. A very unpopular job.

From the analysis above, it is evident that great improvement is possible in the operations of loading, unloading and mowing-away.

It is no wonder that these jobs are unpopular, and that field choppers and balers have been developed to speed up or eliminate or, particularly, to take the "sweat and muscle" out of these jobs.

Yet, for the farmer handling an ordinary amount of hay—say, perhaps 40 or 50 tons—these expensive machines seem hardly practicable from the viewpoint of expense, if sufficient labor can be hired to help do the work as described above—the hard way. The operations of cut-

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ting and raking are common to all systems of hay making. Traveling the length of a windrow with a field chopper is not necessarily more rapid than traversing it with a hay loader. The difficulty lies in the extreme muscular effort involved in attempting to distribute the hay that a constantly moving loader will deliver onto the rack.

In order to avoid the necessity of great muscular effort in loading the hay, it is evident that the hay must not be carried or moved any great distance, if at all, by hand. To accomplish this, the hay, whether dry, tough or green, should fall from the loader approximately into its final position. If no one is on the load, as may be the case with tough hay for a mow drier, or green hay as in silage, no handling whatsoever is involved, as will be described below. In handling dry hay, however, the operator may wish to take very bulky loads, and to use a man on the rack to tramp the hay and arrange it to some extent.

To accomplish this easy loading, a false floor, or platform should be provided, which will slide toward the front of the wagon, at intervals, until the entire rack is filled. Briefly, it was decided to attach a piece of canvas to a short sliding platform, to accomplish the following several ends: 1) The false floor should not stick out behind the wagon, and interfere with the loader; yet it should always be present for the hay to fall upon since, by this means, very large and long racks may be used, and the load may be put on in several segments. 2) On unloading, the false floor should not project past the end of the wagon, but should simply disappear. Several additional methods of accomplishing this are evident, such as, for example, the endless slatted floor of the manure spreader.

In the fall of 1947, a crude experimental model was constructed at Michigan State College (Figure 1). Since it performed according to expectations, the suggestion was passed on to Mr. F. W. Steere, of Pontiac, who had need for just such a device for loading and unloading green or tough hay at his hay drier, and who proceeded to construct a wagon for his own use. His wagon was used successfully all through the 1948 season.

Fig. 1. The self-loading wagon empty, almost half loaded and completely loaded with ladino clover hay.

Figure 2 shows a general view of the wagon from the rear, with the rear stakes removed. The flat wagon bed was extended on the sides to give as large a platform as practicable—10 x 14 feet. To the short sliding platform, two steel cables were attached, running along the top of the platform, over a roller at the back, then under the rack and back, around a front roller and to the platform. The front roller is equipped to pull the cables, and thus move the platform in either direction. This will be described below. To the short platform was attached a piece of canvas, lying on top of the wire cables, and covering the rest of the flat rack.

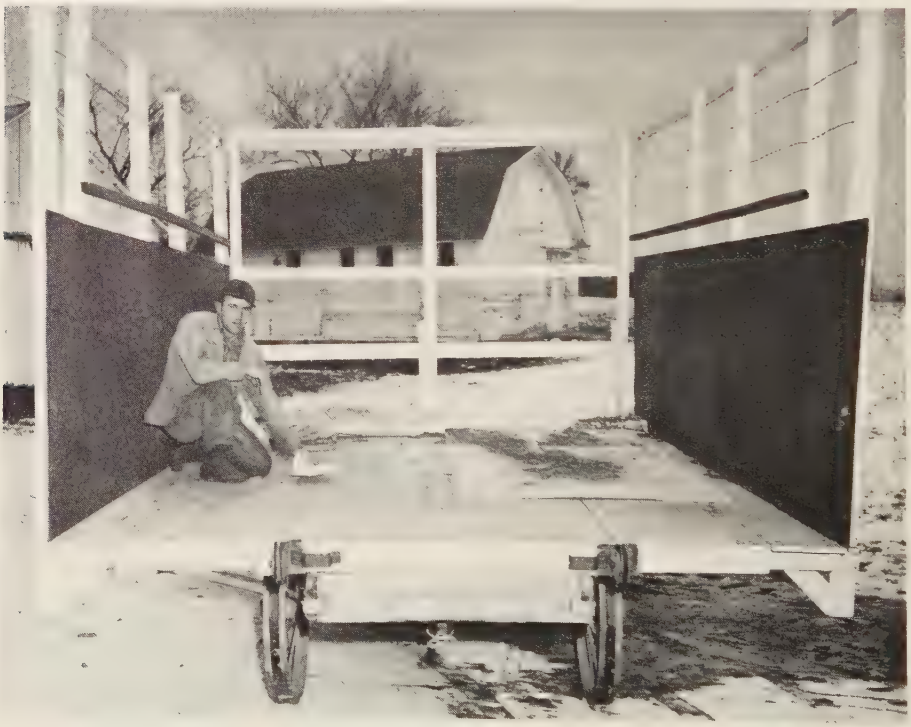

Fig. 2. A general view of Mr. Steere's wagon from the rear, with the rear stakes removed. Note the two cables and the canvas attached to the short sliding platform.

Figures 3 and 4 show a close-up of the arrangement of the cables on the front roller. The cables are wound around this roller in such a manner that as cable is taken up on one side of the anchor, it is played out on the opposite side. Evidently, a sufficient length of cable must be wrapped on the roller so that the platform can be moved approximately

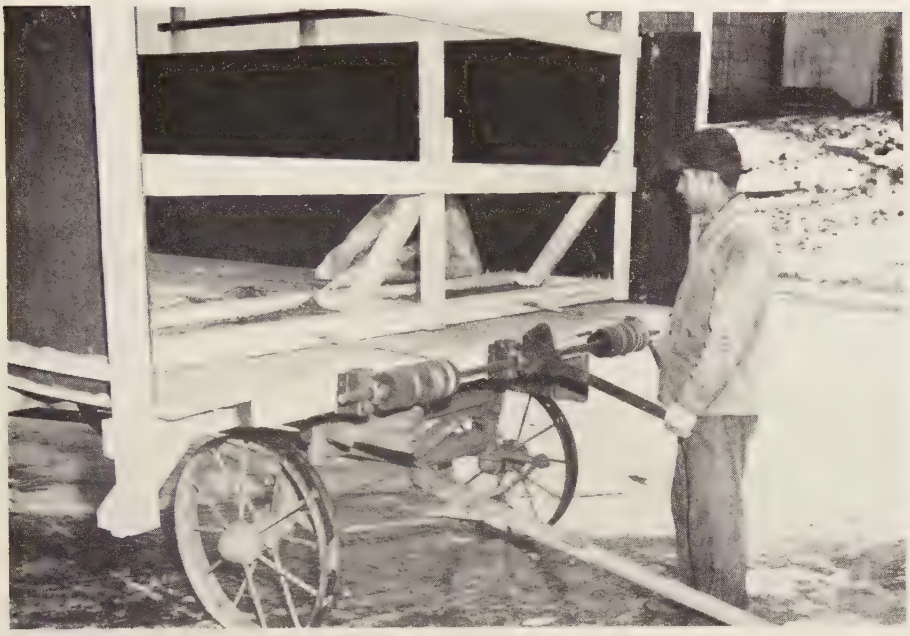

Fig. 3. A front view of the wagon. By lifting up on the lever the operator has slid the platform a few inches toward the back of the wagon. By reversing the ratchet and pushing down on the lever, he can slide it forward.

the length of the rack. Thus, when the platform is at the front of the rack, about 15 feet of cable is wrapped on one side of the anchor, while if the platform is moved to the back of the rack, this cable will unwind on one side of the anchor and appear on the opposite side. An anchor is necessary to avoid slipping of the cable on the drive shaft. The shaft is turned with a lever and ratchet attachment, and, in this case, was operated by hand. One man easily slid the load in either direction.

USE OF THE WAGON AT THE STEERE DRIER

On the Steere farm, all hay is dried artificially. The wagon, loaded with hay, was backed into position at the unloading platform, where the uncured hay was fed by one man into the drier. In the field, no one rode in the wagon. Loads of approximately ¾ ton of dry hay were hauled. Loading was accomplished by pulling the loader off-center on the windrows, first on one side and then on the other. When the hay was piled as high as the loader would deliver it, the platform was pulled forward, and the process repeated until the load was complete.

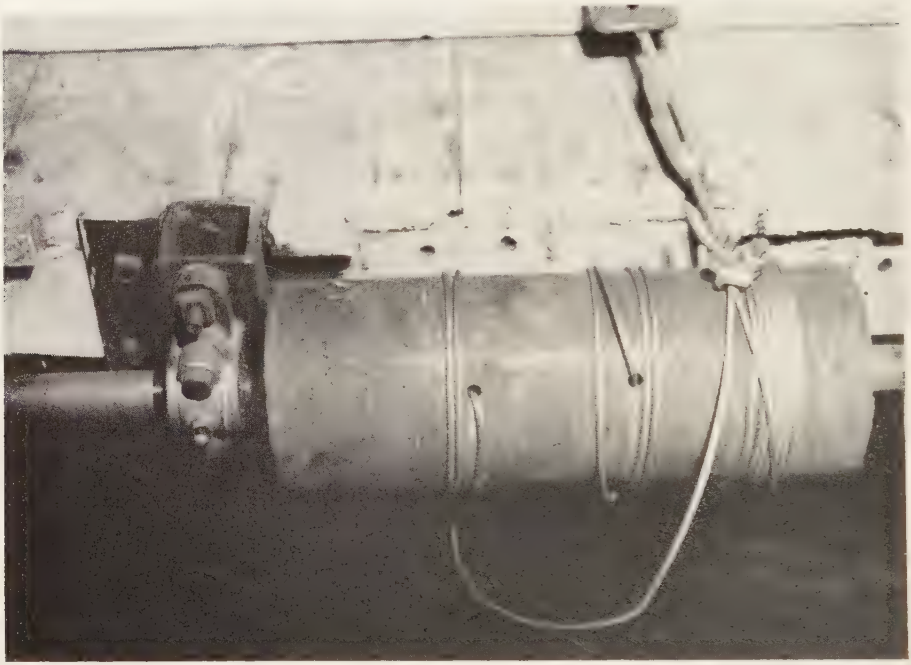

Fig. 4. A close-up of the roll, showing the holes through which the cable is threaded to anchor it. The cable is now wound up on the right of these holes. When the sliding platform is at the rear of the wagon, the cable will be wound up on the left side, having been unwound from its present position.

At the unloading platform, the hay could be taken off conveniently, because the last hay put on was the first hay taken off. Furthermore, the load was in more or less definite segments, and there was much less tangling than when a load has been loaded from the bottom up, rather than from the front, to the back. Periodically the load was pulled back so that it was convenient to the workman who was feeding the drier. This was done by the man in charge of the dehydrator.

The use of this wagon saved the hard labor of at least two men—one in the field, loading, and one at the drier, pitching hay to the feed platform. Both of these jobs are very hard work, when handling damp hay.

USE OF THE WAGON IN ORDINARY HAY MAKING

How to use this wagon will be obvious to the experienced haymaker. One or two points might be mentioned, however.

1) If the long hay is to be unloaded with slings and grapple forks

and the unloading device will not be used, the cables need be arranged only to pull the sliding platform and canvas forward on the wagon. Thus, although the wagon may save much heavy work and time in loading, it may not be helpful in solving the unloading and mowing-away problem in such cases.

2) Yet, if the unloading feature were used in connection with a stationary hay chopper (silo-filler), long-chopped hay might be blown into the barn, and the work of mowing-away completely eliminated. Particularly this should be helpful in the cases where mow-driers are used. It has been a common observation that the field chopper will deliver chopped hay into the wagon faster than the blower will deliver it into the barn. This is a common bottleneck. Furthermore, unloading field-chopped hay is a dusty, dirty job. From past experience, it seems probable that a self-unloading wagon, as described above, might deliver long hay to a stationary chopper and thus to the barn, at least as rapidly as would a blower, and thus save one blowing operation, with its consequent removal and shattering or powdering of leaves. The chopper would deliver the hay to the mow in this case rather than into a wagon.

RAPIDITY IN THE FIELD

In ordinary practice, travel of the hay loader in the field is not only slow, but is greatly interrupted. Yet the load of hay shown in Fig. 1 was put on without stopping the tractor except while the load was being moved forward, and the tractor driver was constantly urged to drive faster than usual, even though the man loading lacked much of the physical stamina common in hay-makers. The windrows, while not large, were the full width of the rake (two 6-foot swaths) and the hay was very tough and heavy. With windrows 12 feet apart, a windrow 3,620 feet long would make one acre. This is approximately 7/10 of a mile. It is evident that with continuous travel of the loader, an acre of hay can be picked up rather quickly.

SIZE OF LOADS

When loading hay in the ordinary way, much of the hay must be dragged, pitched or carried to the far end of the rack. With a rack more than 12 or 14 feet long, this causes great delay when but one man is riding the load. With this device, there seems to be no reason why much longer racks should not be used, since the loading is performed near the loader no matter how long the rack may be.

In a good many instances, as at Mr. Steere's drier, or in making grass silage, there may be little object in trying to haul a load of great volume, since the load becomes very heavy and packed, the wagon wheels tend to cut ruts in the soil, and unloading may become more difficult. Furthermore, our common farm wagons are not constructed to carry these excessive loads. In such a case, this wagon might perhaps be thought of as a modified buck rake, of unusually large capacity.

OPERATION OF MECHANISM THAT SLIDES THE LOAD

In the case of Mr. Steere's wagon, there seemed little to be gained by operating the cable mechanism other than by man-power. In many cases, however, it seems that mechanical operation, as by power take-off might be highly advantageous.

Various substitutions for operation of the cable such as 1) a chain drive, with cog wheels, for the cable drive or 2) a cable (or cog) drive roller at both front and back of the rack, might be made without violating the principles of the wagon described. In Mr. Steere's case, the cable mechanism and the manual operation were considered highly economical and effective, and yet not at all arduous. There seemed, furthermore, nothing to get out of order in this arrangement.

SUMMARY

A wagon has been described that is simple and inexpensive to build and operate; it is partially or entirely self-loading and self-unloading with long hay.

It is suggested that with this device, hay making may be speeded up and the heavy manual labor materially decreased with but little capital investment.

FACTORS AFFECTING THE DESIGN OF A MILK HOUSE

By JAMES S. BOYD

SECTION OF AGRICULTURAL ENGINEERING

MILK PRODUCTION is one of Michigan's largest industries, accounting for about a fourth of the total annual farm income (6). Sixty percent of this production is handled in the farm milk house. Much of the milk is produced on general farms, and it has been found that chore time accounts for half of the yearly work on these farms. Bookhout (2), in a survey made of 10 Michigan farms, indicates that 18 percent of the chore time with dairy cattle is spent cleaning utensils and caring for milk. Through observation, it has been found that these chores were accomplished more effectively in a properly designed milk house.

Two general classes of milk are sold from the farm—market milk and manufacturing milk for the condensary and cheese plant. These two types of milk markets require different sanitation standards; the fluid milk market is very strict in its requirements, and farmers are required to provide a milk house in which to handle milk. The condensary market is less strict, and many farmers have found a milk house a place where they can do the milking operations with the least possible work. Fluid milk is consumed in essentially the same form as it is produced and cannot be cleaned like other farm products. Pasteurization renders good milk safe, but will not make poor quality milk good. Efforts to improve milk supplies have been gradual throughout the United States, but they have noticeably accelerated as the use of market milk has increased in comparison with that of manufacturing milk.

It is generally accepted that a suitable milk house is essential to a quality milk production program. The attitude of health departments regarding milk houses has changed, and not by accident. For example, Parker (4) in 1917, indicated that the best location for a milk house was from 150 feet to 200 feet from the stable. Since that time, changes have been made in procedure and equipment which make possible a

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much more convenient location. For instance, the installation of pressure water systems is simplified by attaching the milk house to the stable. The cleaning of milking machines with vacuum lines from the milking machines, the use of electric coolers, and the new methods of controlling flies have made it possible to increase the usefulness of a milk house by attaching it to the barn.

McMillan (5) found that milk did not absorb odors from the air, which had been a factor in the location of the milk house a distance from the barn. In his study, milk which had been exposed to stable odors for one and one-half hours did not absorb them unless the foreign matter causing the odors was allowed to enter the milk. Because of this and other similar studies, it was generally agreed that the milk house could be located close to the barn without contaminating the milk with odors.

REASONS FOR A MILK HOUSE STUDY

In 1946, health authorities renewed a concentrated program to improve the quality of market milk. It was generally accepted that a milk house was important to such a program and a building plan which could be used throughout the state would help this program. It was estimated that 10,000 new milk houses would be constructed in Michigan in the following five years. Health authorities and dairy inspectors, who were interested in the program, desired a plan which would fulfill the milk ordinance requirements. The farmers, who were to build these milk houses, wished to be sure that they would not have to rebuild in a short time because of their milk houses becoming obsolete. The average cost of the milk houses would be about $300, depending on the amount of native materials and the farmer's own labor used.

Ten thousand milk houses, costing approximately $300 per unit to build, would represent an investment of $3 million. If this investment were to be made by industry, very careful planning would be employed to be sure that the best possible building would be constructed. It is equally important that a farmer give careful consideration to the construction of each unit he builds.

REGULATIONS GOVERNING THE PRODUCTION OF MILK

The milk ordinances in the state are the governing rules in milk house construction and will regulate the type of milk house built in

TABLE 1—*Milk ordinance requirements for major Michigan markets, November 1947*

Area	Minimum size	Electric cooling	Milk strained in barn	Utensils washed in barn	Hot water	Location	Cooling and refrigeration	Utility rack
Lansing[21] 1946	none	no	no	no	no	free from contaminating areas	60° within one hour	
Mich. Milk[24] Ord. 1945	none	no	no	no	no	same as above	60° within one hour	12″ above floor
Grand Rapids[27] 1942	none	no	no	no	yes	same as above	50° immediately	
Bay City[18] 1940	none	no	no	no	yes		60° within one hour	
Pontiac[26] 1945	20 Gal. 10′ x 12′ 20-50 Gal. 12′ x 12′ 50-100 Gal. 12′ x 14′ 100 Gal. 12′ x 16′	no	no	no	yes	50′ from chickens, hogs or privy	55° immediately	12″ above floor
Detroit[19] 1947	10′ x 12′ recommended	no	no	no	yes	same as above	60° within one hour	12″ above floor
Chicago[23] 1937	none	no	no	no	yes	free from contaminating areas	65° within one hour	
(Kalamazoo)[29] Fed. Security Agency 1939	none	no	no	no	yes	same as above	50° immediately	
Flint[22]	0-15 Gal. 10′ x 12′ 15-25 Gal. 12′ x 14′ 26-50 Gal. 14′ x 16′	no	no	no	yes	same as above	60° within one hour	
Ann Arbor[17] 1947	none	no	no	no	no	same as above	60° within one hour	12″ above floor
Saginaw[28] 1942	none	no	no	no	no	same as above	60° promptly	well ventilated
Battle Creek	none	no	no	no	yes	free from contaminating areas	60° within one hour	metal 12″ above floor
Jackson[20]	none	no	no	no	no	not specified	60° immediately	required

the different areas of the state. Twelve large cities in Michigan have dairy plants buying milk and have ordinances controlling the production of this milk. These ordinances have been reviewed and the sections pertaining to milk house construction summarized as shown in Table 1.

From this summary it was found that there was general agreement on items of equipment, but there were differences of opinion as to the size of the milk house.

EQUIPMENT RECOMMENDED FOR A MILK HOUSE

The interviews and field investigations made revealed three main operations that fieldmen and inspectors watched for, and which occur at each milking and have proved essential to the production of high quality milk. These operations are: 1) cooling and storing milk, 2) cleaning and sterilizing equipment, and 3) storing equipment between milkings.

To accomplish these operations most effectively, four items of equipment must be included in the milk house; namely, a milk cooler, a water heater, a double wash vat, and a can rack.

These items of equipment are important to the marketing of clean milk but even when all these are provided in a milk house, the operator cannot be assured of the highest quality milk. This equipment will make the chore easier and help to encourage the production of clean milk, but the farmer still has to do his part. His habits and practices will have a big effect on the quality of milk marketed.

FLOOR AREA REQUIREMENTS

The most variable requirement for milk house construction is the floor area required. Jennings (3) found that the floor area per can necessary to provide adequate space varied inversely as the number of cans produced, and varied somewhat according to the location of the milk house. With milk houses attached to the barn, he recommends a larger floor area than when the milk house is separate from the barn.

The calculated floor area for the milk house equipment is shown on Fig. 1. The space required for the water heater and the wash vats is constant for the range of production considered. The space required for the can rack will vary directly with the number of cans produced and space should be provided for the maximum daily production

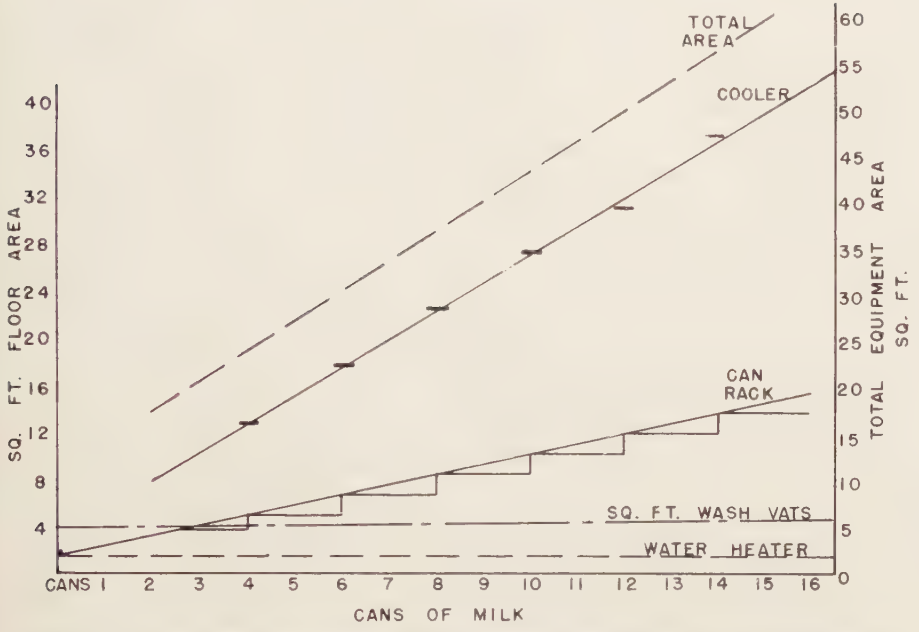
TOTAL AREA
COOLER
CAN RACK
SQ. FT. WASH VATS
WATER HEATER
SQ. FT. FLOOR AREA
TOTAL EQUIPMENT AREA SQ. FT.
CANS OF MILK
CANS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
0 4 8 12 16 20 24 28 32 36 40
0 5 10 15 20 25 30 35 40 45 50 55 60

Fig. 1. Floor area requirements for necessary equipment in a milk house.

anticipated. The can rack provides the necessary facilities for keeping the milk cans clean after they return from the dairy plant. This rack should be constructed so that the other utensils used in the milking and cleaning operations may be kept clean.

The space necessary for the milk cooler will also vary directly according to the number of cans of milk produced. This area was calculated on the assumption that only one unit would be used to cool the daily supply of milk. The curve does not start at the origin of the chart because the space necessary for the compressor and motor would be constant for any type of cooler. When two units are to be used to cool the milk, the cooler space will be larger by the amount of space needed for the refrigeration unit.

Figure 2 indicates the floor area required to provide space for equipment and for operation of the equipment. Curve 1 shows the work area necessary to operate the equipment previously described. Curve 2 shows the total calculated floor area, and the difference between curves 1 and 2 represents the floor area required by the equipment. The area required by the milk ordinances is a straight line, curve 3, and the size varies as the number of cans produced. The farmers, in

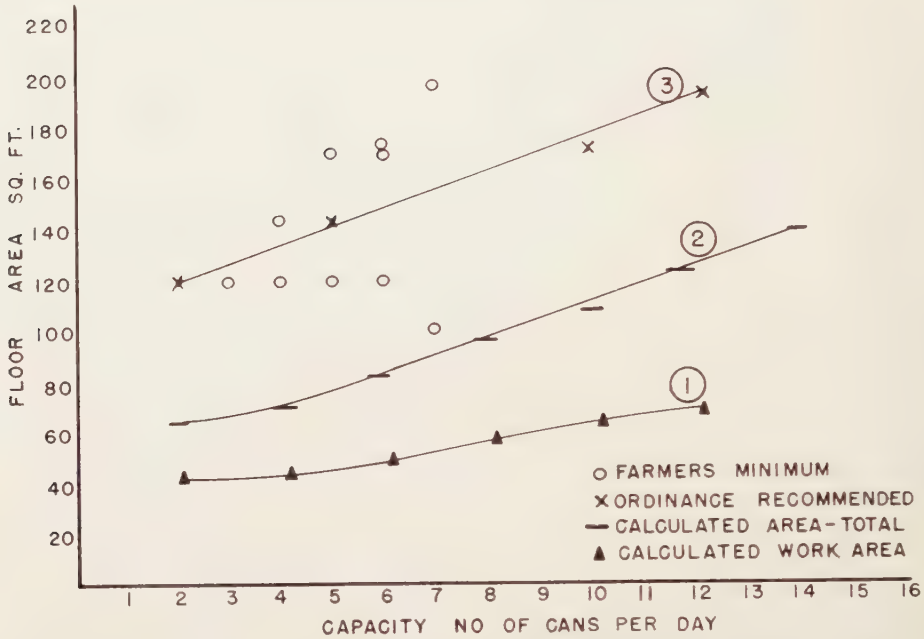

Fig. 2. Total floor area required by milk ordinances, suggested by farmers and calculated from space requirements of equipment.

general, indicated that their present milk house was adequate. Jennings (3) found that one out of four milk houses was too small, while only one of eighty milk houses was too large. A farmer should anticipate his maximum production and build his milk house accordingly, but the milk house should not be so large that there will be space for the accumulation of trash.

LOCATION OF THE MILK HOUSE

Bookhout's studies show that the amount of work done in the milk house varies considerably. The time spent in the milk house, daily, varied from 5.2 to 50.47 minutes. The farm operators studied were milking herds of various sizes, but there was only slight correlation between the number of cows milked and the time spent in the milk house. This indicated that there must be some other reason for not using the milk house for a larger proportion of the milking operations.

A curve was plotted to show the relation between the distance from the stable to the milk house and the minutes spent in the milk house,

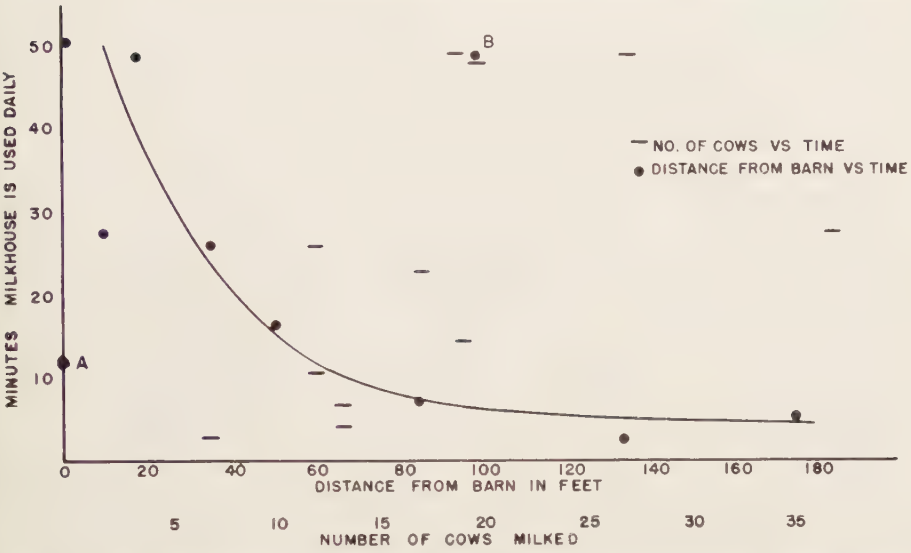

Fig. 3. The effect of location and number of cows on time spent in a milk house.

Fig. 3. This shows that the closer the milk house is to the barn, the more times it was used during the day. Individual farms were studied to determine the operation performed in the milk house, and it was found that the farmer whose milk house was located conveniently to the stable performed more operations in his milk house. The farmer who built his milk house some distance from the barn found it more convenient to perform some operations in other buildings on the farm, which resulted in additional time and travel in doing the chores.

The wide variation in the milking procedures used also affected the time spent in the milk house and the time required to milk the cows. The farmer represented by point A (Fig. 3) attached his milk house to the side of the barn, but was not using the available facilities. His utensils were carried to the kitchen to be washed, and the milk house was used merely as a shelter for the cooler. The farmer represented by point B was also unusual. On this farm, the milk was taken to the milk house and the utensils to the house for washing and sterilizing. The farmer then returned to the milk house and cooled the milk with a small portable cooling unit that had to be changed from one can to the other until the milk cooled.

RELATION BETWEEN TEMPERATURE AND LOCATION

In the milk houses studied in this investigation it was found that the milk houses which were attached to the barn were in general

warmer than the one located apart from the barn. The proportion of days with freezing temperatures was less and the heat necessary to prevent freezing was considerably less.

By having one wall common to the barn and the milk house, some heat is obtained from the barn. The milk house will be protected in many instances from the wind.

SUGGESTED LOCATIONS FOR A MILK HOUSE

The study revealed that the locations shown in Fig. 4 are common in Michigan. The locations shown inside of the barn and the locations

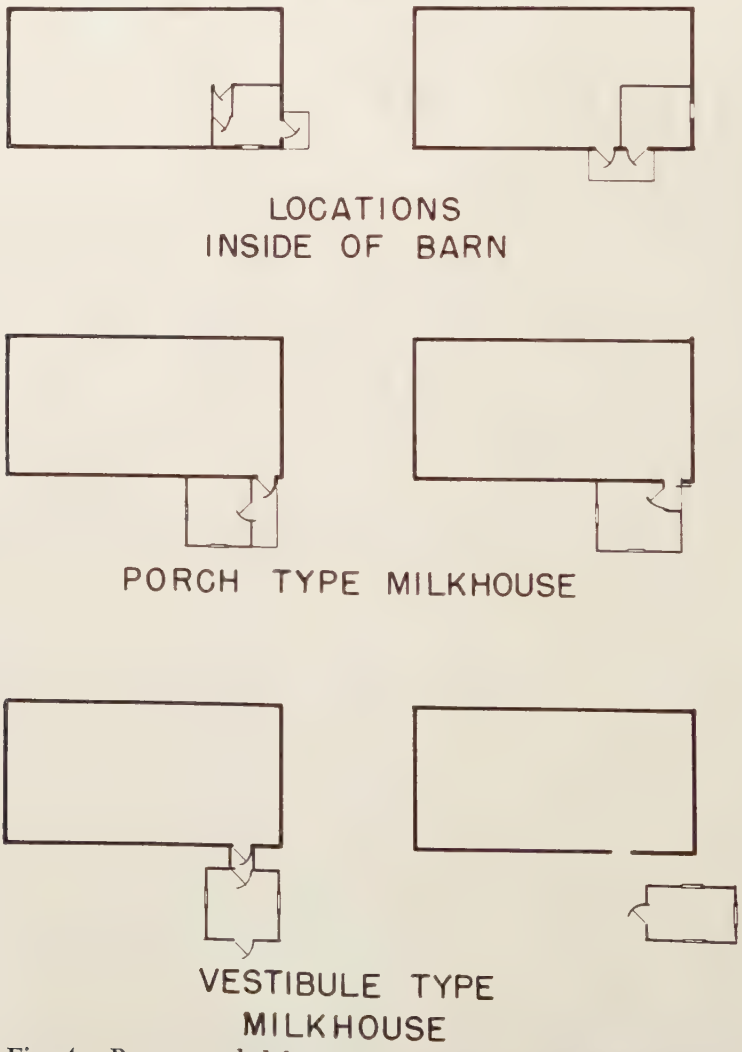

Fig. 4. Recommended locations for milk houses in Michigan.

Fig. 5. Experimental milk house, Michigan State College.

showing the porch-type milk house are recommended to make the milk house functional the year around.

Figure 5 shows a milk house built close to the barn and located so that milk can be easily taken from the stable to the milk house for straining and cooling. Figure 6 shows the plan for a Type-A Milk House which will be approved by all of the city ordinances studied. This plan allows sufficient room for the necessary operations and equipment for the production of quality milk. Other types of milk houses can also be used and plans are available for the various types of milk houses.

CONCLUSIONS

1. A milk house is a structure which, if properly used, will save time and labor on a dairy farm and will make the production of high quality milk easier.

2. The equipment recommended as essential in a milk house includes:

a. A milk cooler
b. A wash vat (double)
c. A water heater
d. A can rack

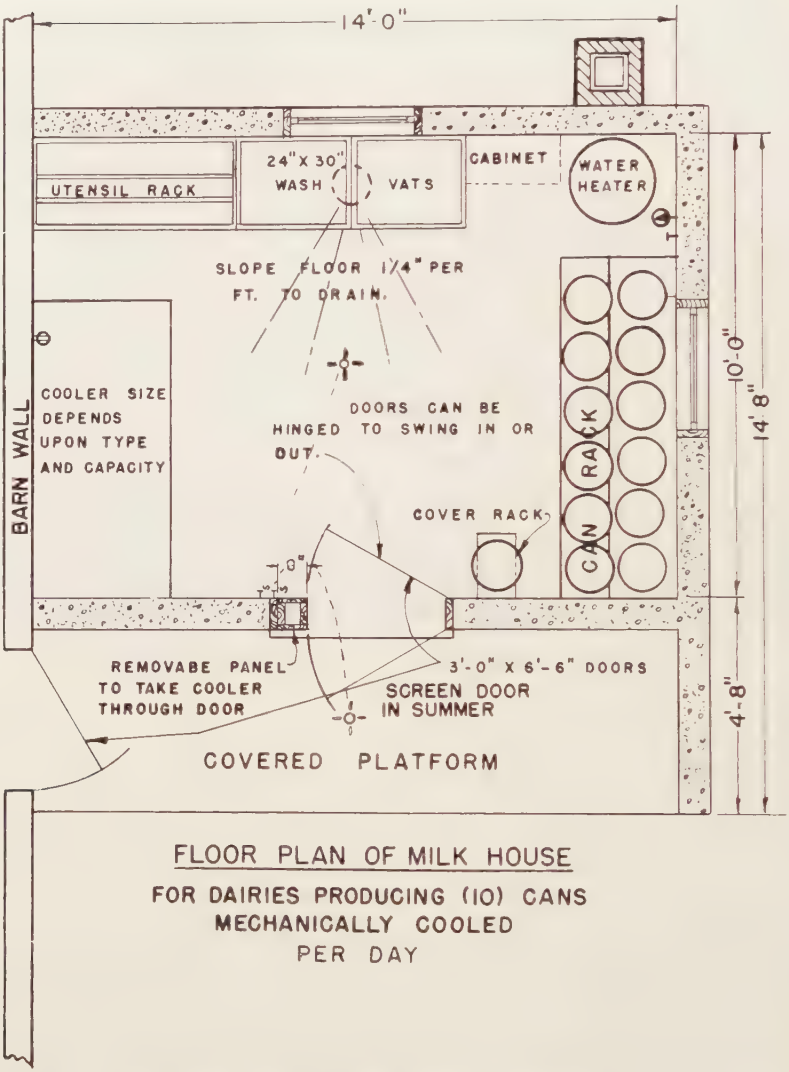

Fig. 6. Plan for a type "A" milk house approved by the 12 major milk markets in Michigan.

3. The floor area requirements of a milk house depend on the size of herd and should not be large enough to allow trash to accumulate. A farmer producing six to eight cans of milk daily should have a minimum of 100 square feet in the milk house.

4. The milk house should be located as close to the barn as possible. Locating the milk house in the barn is desirable providing:

a. There is no direct opening to stable.

b. A tight wall is constructed between the milk house and stable.

c. The location will be approved by the inspector buying the milk.

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PROTECTION OF TOMATOES FROM FROST DAMAGE BY USE OF RADIANT ENERGY

By C. M. HANSEN[1] and A. W. FARRALL[2]

On january 1, 1948, the Agricultural Engineering Department of Michigan State College, turned over to the industry for manufacture, complete drawings of an infrared, radiant-type frost control machine, and demonstrated a full-size model. Much research had been done to determine the scope of this machine prior to releasing it for manufacture.[3 and 4] The working model represented two and one-half years of research. Since that time, many units have been manufactured. Many were used in a preliminary field test program during the spring of 1948, under a wide range of conditions, in nine of the eastern and middle western states. Results of these tests were very encouraging. Much of the data obtained from the field tests were of a rather general nature, and it was desirable to obtain further accurate and complete information regarding the performance of these machines. In order to carry out this program, a group of three of the commercially manufactured units were set up and operated in a tomato field on the College farm during the fall of 1948.

OBJECT OF THE TESTS

The principal objectives of the tests were 1) to obtain accurate information relative to the temperature at which protection from frost damage could be obtained under field conditions; 2) to determine the fuel cost per machine, per hour; 3) to determine the number of days the growing season would be extended through the use of these machines; and 4) to study the general operating characteristics of the machines.

[1]Assistant Professor (Research) in Agricultural Engineering.

[2]Head, Agricultural Engineering Department.

[3]Hassler, F. J., Hansen, C. M., and Farrall, A. W. Protection of Vegetation from Frost Damage by Use of Infrared Energy. Mich. Agr. Exp. Sta. Quart. Bull., *30* (3): 339-360. 1948.

[4]Acknowledgment is made of the interest and valuable assistance of the Detroit Board of Commerce, Agriculture Research Committee, in connection with this project.

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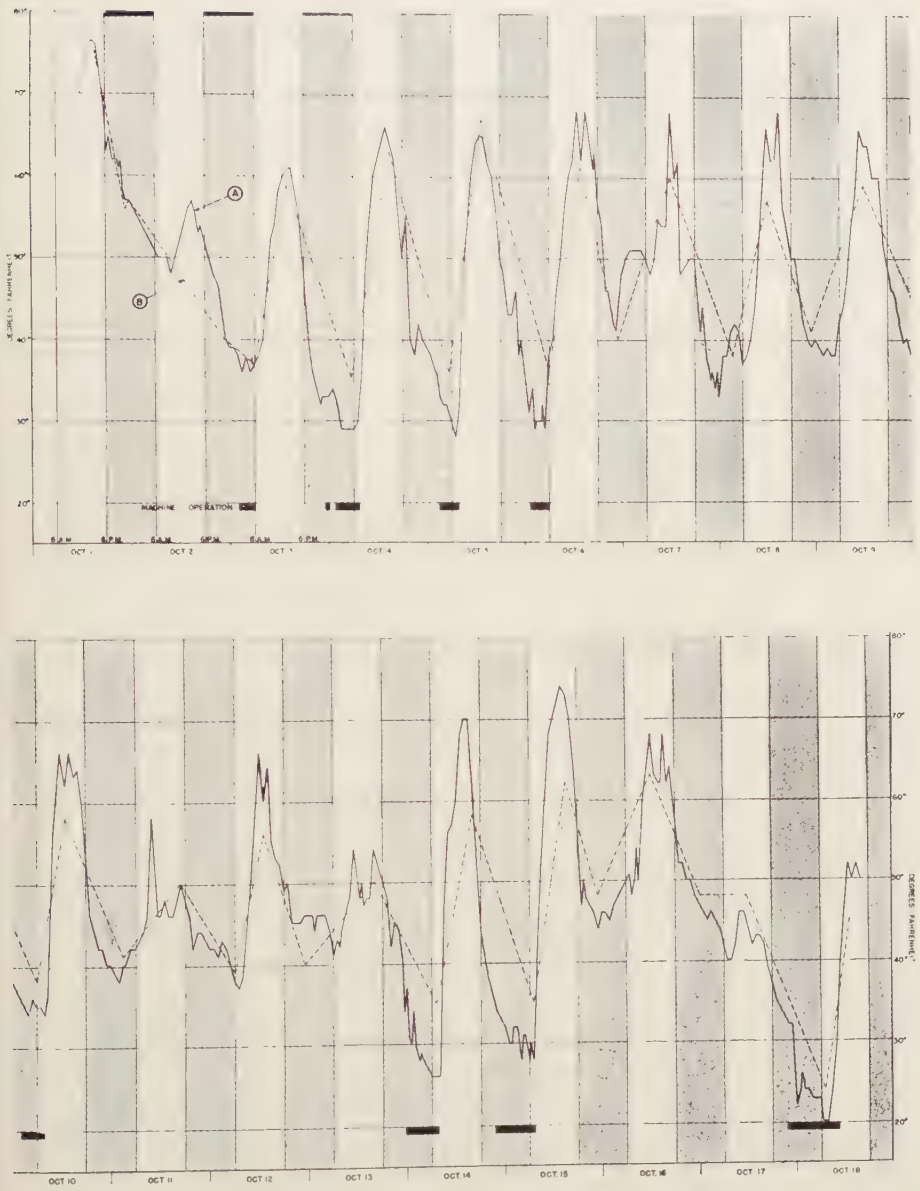

Fig. 1. Log of frost prevention test, fall 1948. "A"—actual temperature in degrees Fahrenheit. "B"—maximum and minimum Weather Bureau temperatures in degrees Fahrenheit.

PROCEDURE FOR TESTING

Three of the radiant-type frost prevention machines were placed in a field having rolling terrain of sandy loam. The field had been planted to a Georgia-grown variety of Stokesdale tomatoes on May 29 and 31, 1948.

The machines were installed on a triangular pattern, having sides of 130 feet, 128 feet, and 100 feet, respectively, in order to study the effect of the different intensities of infrared radiation on the crop. Data secured from previous tests, showed that this installation would give a radiation intensity of not less than 80 microvolts, or 2.65 watts per square foot, to an area of 1.2 acres (Fig. 2). Between units "A" and "B", the intensities were not less than 9.93 watts per square foot, while there was not less than 5.96 and 5.87 watts per square foot between units "B" and "C", and units "A" and "C", respectively.

TEMPERATURE MEASUREMENTS

It was necessary to make a thermo-survey of both the adjacent and surrounding areas, to determine a suitable location, beyond the infrared influence, which would give a true temperature reading of the protected area. Mercury thermometers were calibrated and suspended with the bulb 1 inch above the ground, at various locations. Readings were made under a series of nocturnal conditions. From these readings, a location 400 feet from the frost prevention units was selected which gave a thermo-response the same as in the area adjacent to the machines when they were not in operation. The temperature readings of the two locations had no significant statistical difference.

The recording thermometer which was used, had an exterior coil-type sensitive bulb. This bulb was supported 1 inch above the ground. A mercury thermometer was used to check the accuracy of this unit periodically throughout the course of the experiment. Since the nocturnal readings were of major interest, no attempt was made to shade the sensitive bulb from the sun.

FROST CONTROL OPERATION

The machines were installed in the tomato field on September 20, and checked for mechanical deficiencies. It was determined that the machines were to be turned on when the temperature dropped

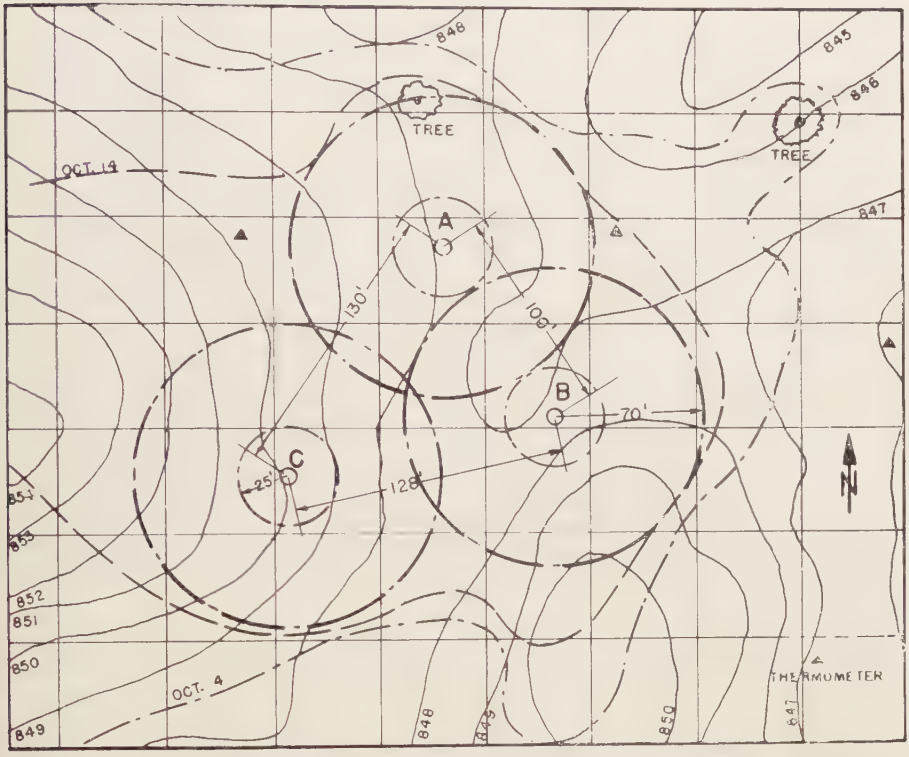

Fig. 2. Location of machines and frost lines on different dates.

to 34° F. They were operated for 4 hours on the night of October 2 as a preliminary operational check (Fig. 1). On the night of October 3, the machines were started at 11:00 o'clock and were operated for one hour; at 1:00 a. m., they were again turned on and operated continuously until 7:20 a.m. October 4 (Fig. 1). On the morning of October 4, the tomatoes beyond the infrared influence were frosted for the first time, to a line indicated on the map (Fig. 2). The line is not definitely defined but is, rather, a band about 12 feet wide, beyond which, all plants were frozen. The walnut trees near the machines, and the topography did influence the frost line; yet, frost occurred at a higher elevation than the area covered by the machines. On this date, the lowest recorded temperature was 29° F. The temperature on the following night dropped momentarily to 28° F., but no further damage was noted.

During the nights of October 4, 5, and 6, the temperature dropped

below 32° F. (Fig. 1), and on each night, the machines were operated for several hours. The temperatures were as follows:

Date	*Time Below 32° F.*	*Min. Temp. in ° F.*
Night of October 4	5 hr., 15 min.	29
Night of October 5	3 hr.	28
Night of October 6	4 hr.	29

At the end of this period, there was no evidence of change in the frost line established on October 4. No further frosts occurred until the night of October 13.

Cold winds on October 13 caused the temperature to drop, and the machines were started at 12 midnight and operated for 8 hours. The temperature was below 32° F. for a total of 7½ hours. It dropped to 26° F. at 6:00 a.m. and remained there for a 2-hour period. Heavy fog accompanied the frost; yet, at no time, was there any within the area of the machines. The topography again influenced the frost line, but the trees no longer assisted in warding off damage to the plants near them.

This same cold wave extended through the night of October 14, when the temperature dropped below 32° F. for 7 hours, with a minimum of 28° F. The machines were operated for 9½ hours.

Fig. 3. Appearance of a tomato plant on October 15 at a point 120 feet from a frost prevention unit, and out of the effective range. Note that the plant has been destroyed by the several frosts which had occurred.

Fig. 4. Photograph of plants on October 15 at a point 70 feet from one unit and 90 feet from another, showing that the leaves and blossoms had not yet been injured by a series of frosts, the lowest of which reached a temperature of 26° F.

Examination of the tomatoes, during the afternoon of October 15, (Figs. 3 and 4) showed complete protection of the plants within a radius of 70 feet from a single machine. The intensity of radiation at this distance was 2.65 watts per square foot, as measured at right angles to the radiation with an Eppley radiation meter. This indicates that the machines could well have been located at greater distances apart, thereby protecting a much greater area. They were so close together that the radiation intensity between units "A" and "B", for example, was 9.93 watts per square foot or greater. An intensity of only 2.65 watts was needed to give ample protection against the 26° F. temperature.

The tomatoes on a hill, west of the machines, were not severely damaged, owing to the difference in elevation. It was noted that there was much white frost on the dead stems and leaves throughout this hill area.

The temperature, on October 17, did not go above 48° F, because there was a "cold front" moving in from the northwest. At about 5:30 p.m., the sky cleared and the temperature progressed steadily down. At 8:00 p.m., the machines were started and operated for 12½

hours. The cool wind, which was never less than 8 m.p.h., carried away more heat from the stems of the plants than could be replaced by infrared energy. The temperature dropped, on the morning of October 18, to 20° F., and remained there for 2 hours. The lowest temperature recorded by the Weather Bureau was 24° F. This reading was taken approximately one and one-half miles distant. The cold front freeze caused a sharp demarcation of the injured and uninjured plants at a radius of 25 feet from the machines.

INFLUENCE OF LOCATION OF THERMOMETER UPON TEMPERATURE READINGS

One of the most important facts, again emphasized by this experiment, was that the temperature, as given by the local Weather Bureau, may be several degrees warmer than that which actually exists on a given field (Fig. 1). For example, on the night of October 3, the Weather Bureau reported a low of 35° F., while on that same night tomatoes which were not under the influence of the machines, were destroyed by frost. Temperature recorded in the field, showed a minimum of 29° F. for a 4-hour period. This is of extreme practical importance because it proves that temperatures for truck crops and other low-growing vegetation must be taken in the field and at a point near the ground. In this experiment, temperature readings were always taken at a point one inch above the ground, with exposed thermometers. If dependence had been placed upon temperature readings taken at an elevation, and under conditions comparable to those of the Weather Bureau, or if regular Weather Bureau readings had been relied upon for determining when to start the frost prevention machines, the tomatoes would have all been completely destroyed. This difference in readings is greater during radiation frosts when no appreciable air movement prevails.

DATES OF FIRST KILLING FROSTS IN MICHIGAN

Usually, there are a number of light frosts which precede the first killing freeze. The fall of 1948 was no exception and, owing to the use of the radiant-type frost prevention units, the growing season of the tomatoes in the protected area was lengthened by 13 days. Normally, the light frosts occur in September and the number of days of lengthened growing season would be much more than this.

On October 18, 1948, the growing season in the vicinity of Lansing, Michigan, was terminated by a wind-borne freeze in which the Weather Bureau temperature was recorded as 24° F., but in which readings at one inch above the ground in the tomato field, showed a temperature of 20° F. It is significant that the killing frosts, as noted by the East Lansing Weather Bureau for the past 12 years, show that in only one year since 1937, has the temperature dropped to 26° F. or below. Usually, it was at 28° to 32° F. (Fig. 5). In all of these instances, it is expected that the frost prevention machines would have given a good measure of protection of tomatoes even against the so-called "killing" frost.

Year	Day of Month	° F.
1937	October 13	26
1938	" 7	28
1939	" 1	28
1940	" 16	30
1941	" 27	32
1942	Sept. 29	29
1943	October 30	33
1944	" 15	27
1945	" 3	32
1946	" 1	32
1947	Sept. 26	32
1948	October 18	24

Fig. 5. Date and temperature of first killing-frost for the past 12 years.

FUEL CONSIDERATIONS

Some difficulty was encountered in the operation of the three 1947-model frost-prevention machines when they were checked for field testing. Inasmuch as the kerosene was stored in a closed container since the spring of 1948, it was felt that the erratic operation might be due to some mechanical irregularity. The burners were cleaned, and the pumps were checked and found to be in excellent condition. Further investigation showed that fuel obtained recently from a distributor made the machines operate properly.

In view of the methods of refining, normally employed in the production of kerosene, it is highly improbable that any appreciable deterioration will occur, even over prolonged periods of storage. Unless

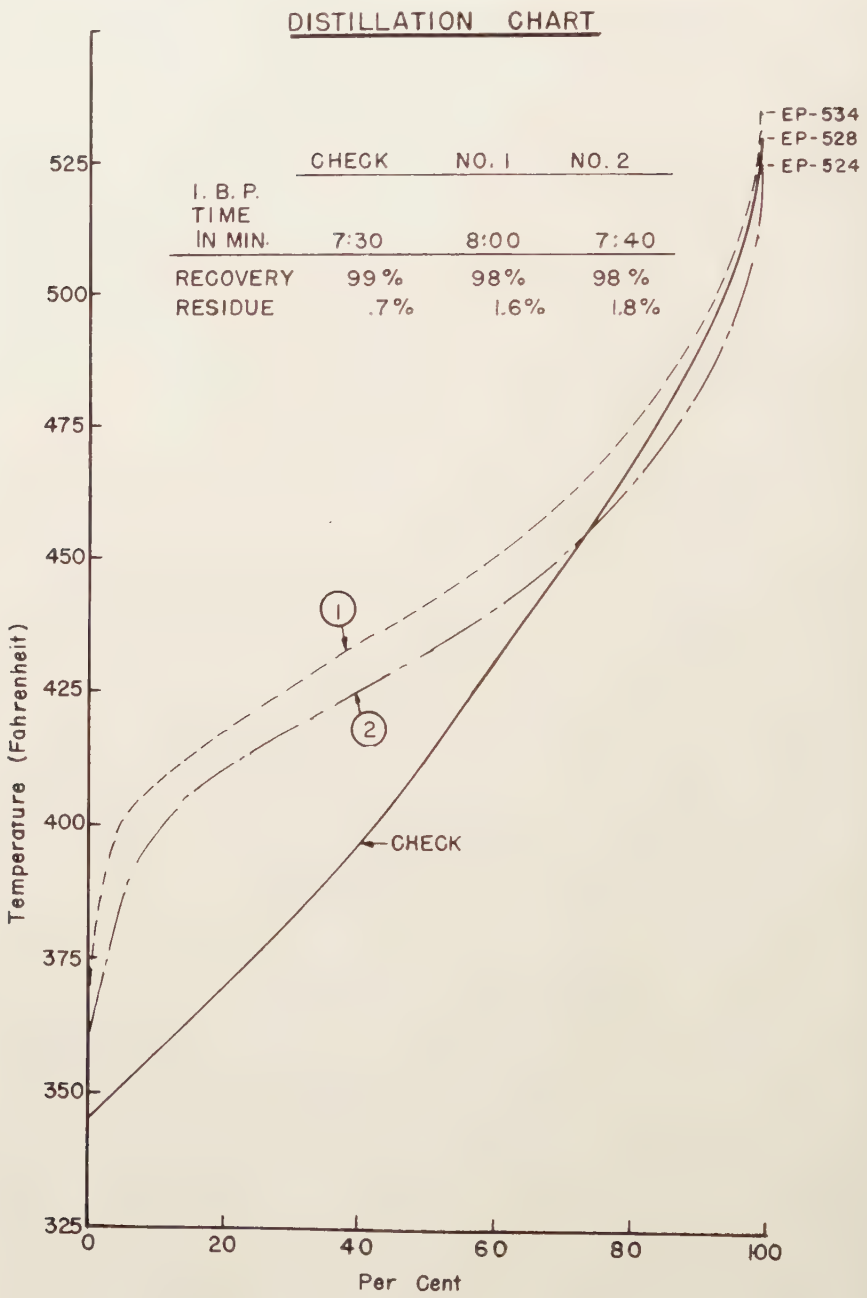

Fig. 6. Distillation chart.

the containers are properly closed, however, it is possible for some of the volatile fractions to be lost, owing to "weathering".

A distillation test was made, and it was found that the volatility of the fuels which would not burn properly, had been seriously affected (Fig. 6). The initial boiling points (IBP) of the fuels No. 1 and 2 (both poor burning), which were held over from April 1948, were 23° and 17° F. higher, respectively, than the checked fuel which burned satisfactorily. The distillation temperatures of No. 1 and 2 fuels remained higher until they reached the 85- and 72-percent marks, respectively. It is interesting to note that these fuels have distillation characteristics which approach those of the A.S.T.M. standards. The IBP time, in this case, is of no significance. End points (EP) of all the fuels tested had a spread of only 10° F., with the No. 2 fuel being less than that of the check. The fact that distillation lines of the No. 1 and No. 2 fuels cross the check at the 72- and 85-percent mark, indicates that this does not have a bearing on proper burning characteristics.

The "light ends" are most important to successful burning in the frost prevention machine. Satisfactory kerosene, for this purpose, should have a maximum 10 percent distillation point of 355° to 360° F., and the 50 percent point should be 415° to 420° F.

STORAGE OF KEROSENE

It is quite evident that the kerosene which is to be used in these frost prevention machines must be stored in a cool place and in a closed container. If 50-gallon drums are to be used successfully, space must be left for expansion of the fuel. This can be easily accomplished by putting only 45 gallons into the drums.

COST OF OPERATION

Accurate records of fuel consumption were kept covering the various tests. It was found that, for a total of 53½ hours of operation, the average hourly consumption of kerosene was 10.8 gallons per machine. With this information, and the fact that a radiation intensity of 2.65 watts per square foot protected tomatoes against 26° F. temperatures, it is possible to calculate, closely, the cost of fuel per acre. When the units are operated in groups of three or more, in order to take advantage of the overlapping radiation from different directions, the maximum efficiency will be obtained.

SUMMARY

During this series of tests, tomatoes under field conditions were successfully protected against damage from a radiation-type frost when the temperature at one inch above the ground was 26° F., outside of the protected area.

Tests also showed that a radiation intensity of 2.65 watts per square foot was necessary to give adequate protection at 26° F., the intensity being measured at right angles to the direction of radiation.

Fuel consumption of the radiant-type, infrared, frost-prevention unit was 10.8 gallons of kerosene per hour.

Kerosene fuel, for these units, must meet a certain standard of volatility.

Temperature measurements must be made *in the field to be protected,* when determining the time to start the radiation units. All thermometers must be exposed to the atmosphere. Weather Bureau or other readings, taken at a distance, do not give a true indication of the temperature condition in a given field.

RESULTS OF IRRIGATION ON VEGETABLE CROPS

By PAUL E. SCHLEUSENER, F. W. PEIKERT, and R. L. CAROLUS
SECTIONS OF AGRICULTURAL ENGINEERING AND HORTICULTURE

TESTS WERE conducted during 1948 to determine the effect of different amounts and times of irrigation on the yields of the following vegetable crops:

Snap beans (Stringless Green Pod and Brittle Wax)
Tomatoes (Stokesdale and Wisconsin 55)
Sweet corn (Golden Cross Bantam and Erie)

The crops were grown near East Lansing on a Hillsdale sandy loam soil which was rather low in fertility. A pre-planting application of 800 pounds per acre of 3-12-12 fertilizer was drilled over the entire area. Water used for irrigation was pumped from a stream adjacent to the field.

Quick-coupling portable pipe carried the water to the plots, and it was applied through a group of fixed type sprinklers attached to

Fig. 1. Irrigation of plots with fixed-type sprinklers.

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a supply line supported on stands in the middle of each plot. A combination of full, quarter and half-circle sprinklers were used to obtain uniform distribution of water. Fig. 1 shows some of the plots being irrigated. This particular type of equipment was selected because of its adaptability to plot work, and would not be recommended for farm use. In the irrigation of vegetable crops produced commercially in Michigan, quick-coupling portable pipe is being installed either with revolving sprinklers or perforations. Fig. 2 shows a typical system in operation.

TREATMENTS

The following irrigation practices were compared:

1. Unirrigated.

2. Irrigation when needed, as determined by gypsum moisture blocks placed at 4 and 8 inches in the soil.

3. One inch per week whenever the rainfall for the previous week did not total one inch.

4. One and one-half inches per week whenever the rainfall was less than 1½ inches during the previous week.

Irrigation for treatment 2 was begun when the blocks showed that available moisture in the soil was less than 50 percent.

Treatments were randomized in 15- by 35-foot plots, with three replications. Ten-foot alleys were left between each replication of plots.

Fig. 2. Irrigation of potatoes with portable pipe sprinkler equipment.

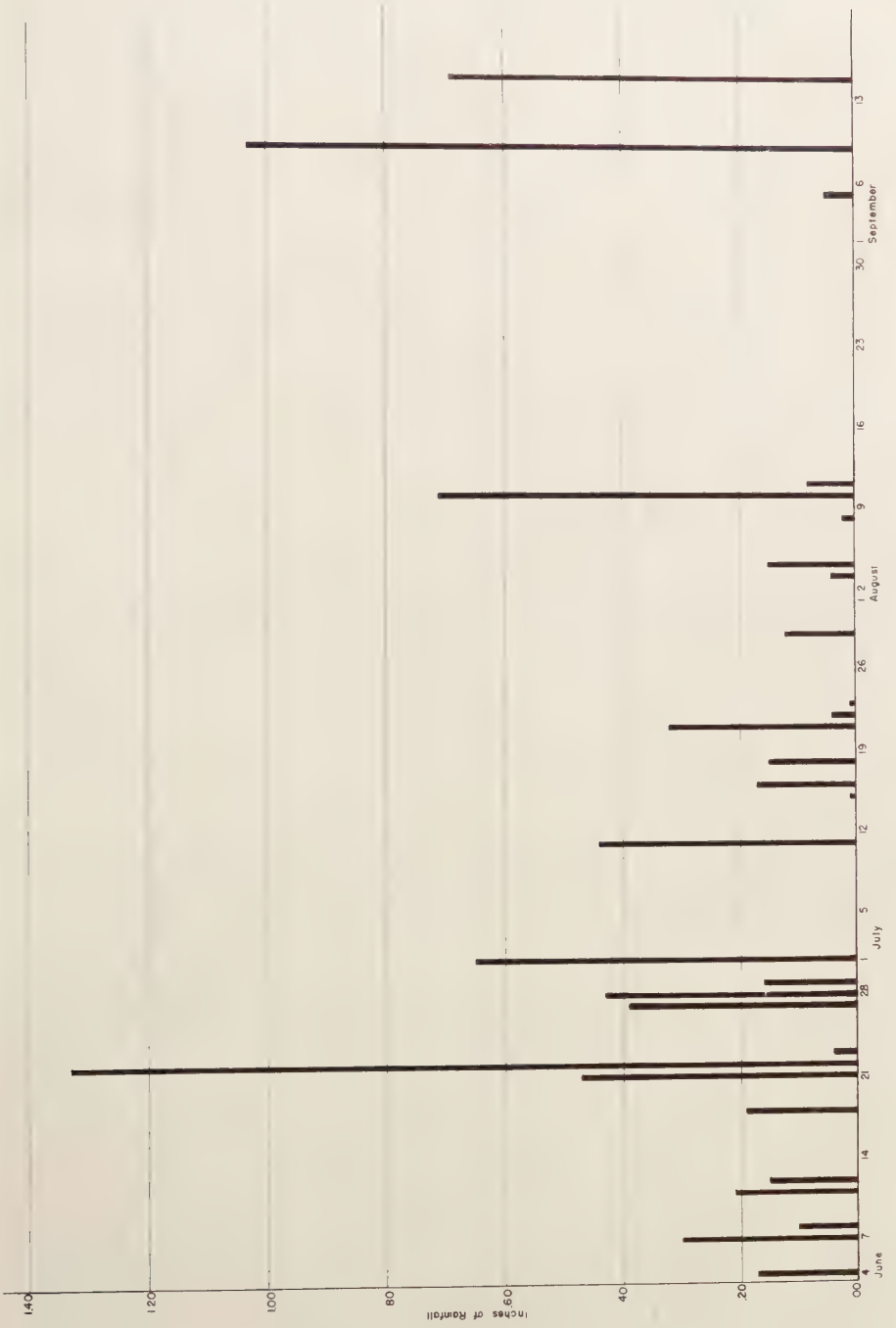

Fig. 3. Rainfall on irrigation test plots, Okemos, Michigan, 1948.

TABLE 1—*Rainfall on irrigation test plots, Okemos, Michigan, 1948*

Date	Amount in inches	Date	Amount in inches
June 4	0.17	July 16	0.17
June 7	0.30	July 18	0.15
June 8	0.10	July 20	T
June 11	0.21	July 21	0.32
June 12	0.15	July 22	0.04
June 18	0.19	July 25	0.01
June 21	0.47	July 27	T
June 22	1.33	July 29	0.12
June 23	0.04	August 3	0.04
June 27	0.39	August 4	0.15
June 28	0.43	August 8	0.02
June 29	0.16	August 10	0.71
July 1	0.65	August 11	0.08
July 10	T	September 5	0.05
July 11	0.44	September 9	1.03
July 15	0.01	September 15	0.69
		Total for season	8.62 inches

WEATHER CONDITIONS

Table 1 and Fig. 3 show the rainfall during the growing season, June 1 to September 15. The rainfall in this three and one-half month period was 8.62 inches as compared with an average for this area of 10.93 inches.

It can be seen that there were two rather long periods in which there was no rain. The first was for 10 days from July 1 to 11. The second was of 25 days duration from August 11 to September 5, which was particularly injurious to the unirrigated corn and to several other crops such as melons and cucumbers grown in the area.

During the rest of the season the rainfall was well distributed, however there was a deficiency in moisture during the latter half of July and first week in August. There was rain on 10 different days, but in every case it was very light.

RESULTS

Snap Beans

The Stringless Green Pod and the Brittle Wax varieties of snap beans planted June 1 were in adjacent rows. The stand of the wax beans was satisfactory but that of the Green Pod was quite broken which probably influenced the yields obtained with the various irrigation treatments. The first picking was made August 1.

TABLE 2—*Results with snap beans*

Treatment	1 Unirrigated	2 By blocks	3 1″ per wk.	4 1½″ per wk.
Water applied		2″	8″	15½″
		Brittle Wax		
Yield in lb./acre	4,124	5,842	6,390	6,888
Percent increase in yield		41	55	67
Net value of increase per acre*		$28.90	$30.15	$34.71
		Stringless Green Pod		
Yield in lb./acre	4,066	3,925	5,311	5,029
Percent increase in yield		—3.5	31	24
Net value of increase per acre*		$23.15 loss	$1.56	—$15.72 loss

*The cost of applying water includes depreciation and repairs on equipment, interest on investment, cost of power and labor for irrigation.

Canner's price for beans—5c per pound.

Cost of picking and marketing the increased yield—2.2c per pound.

In Table 2, the data indicate that for wax beans an application of as little as 2 inches of water increased the yield 41 percent . With 6 inches additional water the yield was increased an additional 14 percent. The Brittle Wax variety shows the most profitable increase per inch of water, with the total application of only 2 inches. Because of the broken stand, the results on the green beans are too variable to be reliable.

Tomatoes

Plants of the Wisconsin 55 and Stokesdale varieties of tomatoes were set May 31 in irrigated soil. As a result of sufficient moisture very little replanting was necessary. Harvesting extended from August 24 to October 1.

Climatic conditions were quite favorable and resulted in high tomato yields in this general area. The data in Table 3 indicate that in both varieties the plants receiving 4 inches of irrigation water during the season produced larger increases in total weight than others receiving three to four times as much water. In the Wisconsin 55 variety the application of 4 inches of water resulted in 63 percent increase in total weight; with the Stokesdale variety the same treatment produced an increase of 69 percent in total weight.

The number and weight of fruit on plots receiving either 11 or 16 inches of water were substantially lower than those on plots receiving 4 inches of water. In this experiment the heavy irrigations resulted in

TABLE 3—*Results with tomatoes*

Treatment	Water applied	Yield			Net value of increase per acre*
		Bushels (acre)	Number of tomatoes (thousand/acre)	Average weight of fruit	
WISCONSIN 55					
1 (unirrigated)	.....	472	86.8	.33	.....
2 (by blocks)	4″	771 +63%**	121.0 +39%	.38 +15%	$245.20
3 (1″ per week)	11″	585 +24%	92.9 + 7%	.38 +15%	61.35
4 (1½″ per week)	16″	597 +26%	93.7 + 8%	.38 +15%	67.90
STOKESDALE					
1 (unirrigated)	.....	529	89.9	.36	.....
2 (by blocks)	4″	895 +69%	133.5 +49%	.40 +11%	$305.50
3 (1″ per week)	11″	682 +29%	103.4 +15%	.40 +11%	97.35
4 (1½″ per week)	16″	681 +29%	108.5 +21%	.38 +5.6%	92.20

*The cost of applying water includes depreciation and repairs on equipment, interest on investment, cost of power and labor for irrigation.

Fresh market price for tomatoes—$1.50 per bushel. Cost of picking and marketing the increased yield—60c per bushel.

**Percentages are increases in yield as compared with the yield of unirrigated plants.

a lower fruit set. The size of fruit was increased up to 15 percent by irrigation and was not influenced by the amount of water applied.

The data show that irrigation was very profitable on tomatoes.

Sweet Corn

Two varieties of sweet corn, Erie and Golden Cross Bantam, were drilled in 3-foot rows on June 1. The plants were thinned to an average stand of 132 stalks per hundred feet of row.

During the latter part of August, the unirrigated corn showed the effects of drought by the rolled leaves and a difference of about 12 inches in height. The corn was picked on August 30 and September 5.

The corn was weighed and counted. The data in Table 4 show the average weight per ear, the total weight, and dozens of harvested and marketable ears to the acre.

Corn was benefited more by irrigation than either of the other

TABLE 4—*Results with sweet corn*

ERIE

Treatment	Water applied	Dozens of ears per acre harvested	Dozens of ears per acre marketable	Percent marketable	Tons per acre harvested	Average weight of ear	Net value of increase per acre*
1 (unirrigated)	.....	1126	363	32.2	2.77	.41	.....
2 (by blocks)	4″	1516 +34%**	1297 +257%	85.6	5.82 +110%	.64 +56%	$162.90
3 (1″ per week)	8″	1354 +20%	1163 +221%	85.9	5.20 +88%	.64 +56%	$126.70
4 (1½″ per week)	14½″	957 −1.5%	793 +118%	82.9	3.10 +12%	.54 +32%	$44.18

GOLDEN CROSS BANTAM

1 (unirrigated)	.....	1208	229	19.0	2.61	.36	.....
2 (by blocks)	4″	2026 +68%	1668 +628%	82.3	6.32 +142%	.52 +44%	$263.90
3 (1″ per week)	8″	1539 +27%	1237 +440%	80.4	4.71 +80%	.51 +42%	$168.30
4 (1½″ per week)	14½″	1189 −1.6%	699 +205%	58.8	2.71 +3.8%	.38 +6%	$52.18

*Cost of applying water includes depreciation and repairs on equipment, interest on investment, cost of power and labor for irrigation. Fresh market price for corn—30 cents per dozen ears. Cost of picking and marketing the increased yield—10 cents per dozen ears.

**Percentages are increases in yield as compared with the yield of unirrigated plots.

crops. An increase of 257 percent in the number of dozens of marketable ears of Erie variety resulted from the application of 4 inches of water.

In the Golden Cross variety a similar application of water resulted in an increase of 628 percent. This variety had less than 20 percent of the ears marketable on the unirrigated plots while on the irrigated plots over 80 percent of the ears were marketable. The Erie variety produced 32 percent marketable ears on the unirrigated area, while irrigation increased the marketable ears to 85 percent. These facts indicate that Golden Cross was benefited more by irrigation than Erie. In practice it has been frequently observed that Golden Cross fills very poorly under drought conditions.

Weight per ear was increased 56 percent in Erie and 44 percent in Golden Cross by an application of 4 inches of water. This increased size was due to a longer, better filled ear resulting in better market quality.

CONCLUSIONS

The results of these tests indicate that irrigation in a year of subnormal rainfall during the growing season is a very profitable practice on vegetable crops. Even in years of normal rainfall there are frequently drought periods of sufficient duration to warrant the investment in irrigation equipment.

Under the conditions of this experiment, increased quantities of irrigation water did not result in proportionate increases in yields. In some cases yields decreased with the larger quantities of water.

It was found that sweet corn showed the greatest response to irrigation, with tomatoes and snap beans following in the order named.

The data reported are based on one year's results on a Hillsdale sandy loam soil. Under other conditions the response to irrigation would probably vary considerably. Further investigations of the interrelationship of vegetable crops, soils and irrigation practices under varying seasonal climatic conditions are warranted.

LOSS OF COWS FROM DAIRY HERDS REDUCES INCOME

By RUSSELL E. HORWOOD
SECTION OF DAIRYING

DAIRYING PROVIDES the largest source of income for the Michigan farmer. The production of the state's farm dairy herds accounts for about one-third of the cash income of Michigan farmers. Sale of animals from the dairy herds adds materially to this income. Michigan dairymen now keep approximately 900,000 cows on 150,000 farms.

Dairymen in many cases are not aware of the seriousness of the cow losses in their herds. This is due to a lack of records of the number and causes of cow removal from their herds. The income from the sale of products and cattle could be increased markedly if the losses of dairy cattle could be reduced.

Studies have indicated that replacement rates in dairy herds are high. Investigations by Lush and Lacy (4), McDowell (5), and Smith and Robinson (6) show it is necessary to replace approximately 21 to 28 percent of the milking herd annually. Cannon and Hansen (2) report that 56 percent of all animals in cow testing associations in Iowa were under 5 years of age.

Baltzer (1) reports that a study of Dairy Herd Improvement Associations figures covering six years from 1931 to 1937 reveals that the average milk-producing life of a cow, if all factors are included, is about 3.7 to 4 years. The data indicate that a dairyman must plan to reproduce his milking herd every 4 years.

Lush and Lacy (4) found, from a study of 500 cows in each of the dairy breeds, the productive life of a cow to be 3 to 5 years.

In Iowa (3), it is reported that 26.2 percent of all cows in Dairy Herd Improvement Associations test in that state left the herd annually. Approximately one-third of this number left the herds because of low production, one-third for health reasons and one-third were sold for dairy purposes.

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TABLE 1—*The number and cause of removal of cows by breeds from the College and Sub-station herds during the period 1933-41*

Breed	Reasons for cow removal										Total removed	Total in herd
	Dairy purposes	Low production	Breeding troubles	Mastitis	Bangs and abortion	Loss at calving	To experimental herd	Old age	Udder injuries	Miscellaneous		
College Ayrshire	7	14	3	10	.....	.....	.....	.....	1	1	36	42
College Brown Swiss	3	2	2	4	.....	1	3	.....	.....	3	18	31
College Guernsey	9	5	11	4	1	.....	1	.....	1	2	34	48
Kellogg Guernsey	3	15	8	7	3	1	.....	2	.....	3	42	96
College Holsteins	15	8	12	16	3	2	10	.....	2	4	72	84
Chatham Holsteins	32	10	5	3	.....	1	.....	.....	1	5	57	75
College Jerseys	16	12	5	6	1	2	4	2	.....	5	53	62
TOTAL	85	66	46	50	8	7	18	4	5	23	312	438
Percent of those removed	27.2	21.1	14.7	16.0	2.6	2.2	5.8	1.3	1.6	7.4	100	.....
Percent of total cows removed	19.2	15.1	10.5	11.4	1.8	1.6	4.1	0.9	1.1	5.3	71.0	.....

PROCEDURE

A study was made in the Michigan State College herds covering a period of nine years from 1933 through 1941 to determine the number and cause of dairy cow removal.

The herds consisted of the W. K. Kellogg Sub-station herd at Augusta, made up of the Guernsey breed; the Upper Peninsula Experimental Station, made up of the Holstein breed; and the Michigan State College herd which includes the Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey breeds. See Table 1.

The greatest cause of removal was the sale of cows for dairy purposes. This amounted to 19.2 percent of the total, or 85 of the 438 cows that had freshened. This is 27.2 percent of those removed. Sale for dairy purposes is not considered a loss to the herd.

Each cow removed from the herd for other than dairy purposes normally leaves at a loss to the owner. In case of death this is nearly a complete loss. In other instances the value for beef may be all that

is retained. In some cases the loss may be sufficiently great to require the purchase of outside cattle to maintain the herd.

The greatest cause of loss in this study was due to low production. This agrees with the previous studies cited. Sixty-six animals, or 15.1 percent of the total, were removed for this reason. Another primary reason for removal was disease. Mastitis proved to be the greatest factor. In all, 50 animals, or 11.4 percent, were slaughtered as a result of udder infection.

Breeding trouble was found to be nearly equally important and resulted in 46, or 10.5 percent, being eliminated. Minor losses include 8 cows, or 1.8 percent, being removed because of Bang's disease and abortions and 7 cows, or 1.6 percent, died at calving time. Other causes as udder injuries, old age, bloat, and miscellaneous reasons totaled 11.4 percent. The percentage of the cows removed for each cause is shown in Table 1.

From the data presented it is evident that it is important to reduce the losses of cows from dairy herds. Modern methods of dairying which include the latest developments in breeding, feeding, management and disease should aid in accomplishing this.

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TRANSMISSION THROUGH GRAFT UNIONS OF FORMATIVE STIMULI INDUCED BY 2, 4-DICHLOROPHENOXYACETIC ACID

By A. S. DHILLON and E. H. LUCAS
SECTION OF HORTICULTURE

THE MECHANISM by which 2, 4-dichlorophenoxyacetic acid (abbreviated: 2, 4-D) acts and produces morphological responses in plants is yet unknown. Skoog (2), citing Guttenberg's hypothesis on the mode of action of growth regulators, has suggested the possibility that the release of native-bound auxin in plants treated with synthetic growth regulators like 2, 4-D may result in an excess of free auxins which causes the physiological and morphological disturbances. However, convincing proof is still lacking. Morphological changes as a result of the application of phenoxy compounds have been studied by Zimmerman and Hitchcock (5) and by others. With their similarity to virus manifestations and phenomena associated with induced chromosomal disturbances (3), they have been of interest ever since their first observation. The primary object of the present investigation was to follow up accidental leads which indicated a peculiar mode of transmission through graft unions of stimuli such as produced by the treatment with 2, 4-D and expressed by morphological abnormalities.

EXPERIMENTATION

The tomato, which is highly sensitive to the action of 2, 4-D, was selected for the purpose of this study. Plants of the John Baer variety, 5 weeks old and 30-40 cm. high, were treated by immersing their third basal leaf in a 1000 p.p.m. aqueous solution of sodium 2, 4-dichlorophenoxyacetate during the first week of November 1947; the customary precautions were taken to prevent contamination of other parts of the plants. After displaying the usual nastic effects all plants developed malformations on their terminal parts. Three weeks after the treatment when these effects were well established, reciprocal grafts were made with untreated plants; the method of splice grafting was used.

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Controls included untreated scions grafted on untreated stocks and scions from 2, 4-D treated plants on 2, 4-D treated stocks. Twelve grafts of each group were made. Unions were found established within 7-10 days. Axillary shoots were not allowed to develop on the stock during this period, and for two weeks afterwards. However, subsequently the plants were allowed to grow without being disturbed.

Three months after grafting the symptoms evident on the plants were recorded. Quantitatively, there were considerable differences between the responses of the individual plants. Qualitatively, however, definite trends were noticed. Typical plants of each group are shown in Fig. 1.

Fig. 1. Typical plants of four different graft combinations.
1: Untreated plant grafted on untreated plant
2: Treated plant grafted on treated plant
3: Treated plant grafted on untreated plant
4: Untreated plant grafted on treated plant

The treatments consisted of immersion of the third basal leaf in a 1000 p.p.m. aqueous solution of sodium 2, 4-dichlorophenoxyacetate three weeks prior to grafting (approximately 4 months before the pictures were taken).

The arrows point to the graft unions which are also marked by circular tags.

The modified leaves of the scion of Plant 4 are clearly visible just above the tag bearing the number.

Plant 1. A normal scion was grafted on a normal stock. No peculiarities were evident.

Plant 2. The scion as well as the stock was taken from a 2, 4-D treated plant. No modifications of leaves were noticed with the exception of those which had taken place before grafting. Evidently, the formative stimulus was absent after grafting took place.

Plant 3. A normal stock was grafted with a scion which originally was the apical portion of a treated plant. With the exception of those leaves which were modified before the scion was removed from the original plant no morphologically changed organs were recorded.

Plant 4. A treated stock was grafted with a scion which originally was the apical portion of a normal plant. The foliage of the scion exhibited morphological abnormalities which indicated that the stimulus had been transmitted through the graft union.

DISCUSSION

From the experimental results it would appear that greater quantities of the stimulus were stored in the stock portion, and from there could influence the scion whereas the treated scion contained a smaller amount of the causative agent. Hence, no downward transmission of it took place. However, in other experiments conducted (unpublished data) it became evident that a basipetal movement through graft unions may also occur. Zimmerman and Hitchcock (5) reported that the cut stumps of tomatoes treated with p-chlorophenoxyacetic acid produced many new shoots with modified leaves 30 days after treatment. They mentioned that it was not known whether the growing tips were still under the influence of the chemical applied to the stump or whether genetic changes, such as were induced by colchicine, could have occurred. The present findings indicate that no genetic changes were induced since the modified plants when grafted on normal stocks became normal. The influence extending through the graft union therefore appears to have been a direct transmission of a chemical effect.

The transport of 2, 4-D when applied to leaves has been shown by Mitchell and Brown (1) to be associated with the translocation of organic food reserves. However, as mentioned by Zimmerman and Hitchcock (6) only a few cases have been recorded in which the applied chemical was detected or identified by direct methods beyond the region of application. In fact, no positive evidence seems to exist

pertaining to the entry of 2, 4-D and its translocation as such. Nothing is known about the fate of the substance after its absorption and particularly during the subsequent period when morphological changes take place. The recent work by Wood *et al.* (4) indicates that radioactive 2-iodo-3-nitrobenzoic acid entered bean and barley plants in molecular form and was translocated as such. Under the assumption that 2, 4-D in the present experiment was likewise absorbed, translocated and retained as such for 3 weeks, the conclusion is permissible that it was 2, 4-D that moved through the graft union and caused the modifications of the leaves of the scion. However, until such an assumption can be proved conclusively, it is a matter of speculation whether the causative agent was 2, 4-D or a derivative or even a reaction product.

Since this work was merely undertaken in support of other studies on the relations of stock and scion, the information on the response to application of 2, 4-D must be considered as preliminary. It is being released, however, in order to convey the observations to those working with 2, 4-D and related substances.

SUMMARY

The formative stimulus which resulted from the application of sodium 2, 4-dichlorophenoxyacetate to tomato leaves was transmitted through graft unions from the stock to the scion several weeks after the plant used as stock was treated. The stimulus appears to be a directly transmitted substance, but its chemical nature is not further specified.

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JOURNAL ARTICLE ABSTRACTS

A Comparison of the Palatability of Hatchery-reared and Wild Brook Trout

Baeder, Helen A., Tack, P. T., and Hazzard, A. S.

Trans. Am. Fisheries Soc. 75: 181-185. 1945. [*Journal Article 834 (n. s.) from the Michigan Agricultural Experiment Station*]

Objective organoleptic tests scoring for aroma, flavor, texture, and moisture, were made for eight samples of wild brook trout (*Salvelinus fontinalis*) from two streams and for seven samples of hatchery-reared brook trout from two rearing stations. Samples were obtained during May, June, July and August, were cooked separately by the same method, and identified by the judges by code number.

Average scores of six judges showed all samples acceptable, but values for wild fish from both streams were significantly higher than for hatchery-reared trout. The color of the flesh and the overall appearance of the wild trout were also more attractive.

The possibility of improving the eating quality of hatchery trout through better nutrition was suggested.

Preparation of Crude Plant Extracts and Their Assay for Presence of Antibacterial Substances

Lucas, E. H., Pearson, Kathryn, Lewis, R. W., and Vincent, Betty

Food Research. 13 (1): 82-88. 1948. [*Journal Article 858 (n. s.) from the Michigan Agricultural Experiment Station*]

A method of testing crude plant extracts for the presence of antibacterial substances is described. It consists of a modification of earlier methods used for the determination of antibiotics and adapts them to the purpose discussed. Instead of cups which were used in the Oxford test and its modifications filter paper disks are the carriers of the substances to be tested on an agar medium.

A stable standard of vegetable origin, dehydrated garlic, is introduced in this technique. In the evaluation of the plant materials tested the comparative potency is expressed in terms of garlic units. A number of tables and diagrams supports the evaluation presented.

Characteristics of Michigan's Fringe Population

Beegle, J. A.

Rural Sociology. 12 (3): 254-263. 1948. [*Journal Article 865 (n. s.) from the Michigan Agricultural Experiment Station*]

The age, sex, race and nativity composition as well as the fertility of "fringe" residents in Michigan were studied. Ten major areas around large cities form the focus of attention. Demographic data were secured for the urban center, the fringe (townships having 50 percent or more non-urban, non-village, and non-farm population) and adjacent rural-farm population. Proportions of foreign-born and Negroes in the fringe areas were found to be low. The sex ratio was high, although slightly lower than the adjacent farm population. Proportions of persons under 21 were high, while proportions of persons aged 65 and over were low. Birth rates in these areas were found to be extraordinarily high.

The Influence of Agitating the Freshening Water on the Desalting of Pickles

FABIAN, F. W., AND JACOBS, P. D.

Fruit Products Jour. 26 (8): 230-232, 253. 1947. [*Journal Article 867 (n. s) from the Michigan Agricultural Experiment Station*]

A study was made of the influence of agitation by compressed air on the rate of withdrawal of salt from pickles during the freshening process as compared with non-agitation. The pickles used were vat-run, ranging in sizes from 800 to 1,200 inclusive, and also No. 2 machine-graded pickles which included sizes from 4,500 to 8,000 inclusive. The pickles in the tanks were heated by a steam siphon and the water agitated by perforated galvanized iron pipes attached to compressed air. Two freshening waters were used in both sizes of pickles. The first freshening water of the vat run, sizes 800 to 1,200, showed that the salt was withdrawn faster from the pickles in the agitated than in the non-agitated tanks but at the end of 8 hours the salt remaining in the pickles was, however, found to be 1 percent less in the non-agitated than in the agitated tanks. After the second freshening, which consisted of allowing the pickles to stand in water overnight, the salt content was 1 percent less in the non-agitated than in the agitated tanks. The same results were obtained from the two freshening waters of the No. 2 vat machine graded pickles sizes 4,500 to 8,000. These results show that when the water is heated by means of a steam siphon there is no significant difference on the rate of withdrawal of salt from pickles when the covering water is agitated with compressed air. However, the agitation of the water does help to remove any dirt adhering to them.

The Lixate Method of Salting Cucumbers

FABIAN, F. W., AND BLUM, H. B.

Fruit Products Jour. 27 (4): 103-106. 1947. [*Journal Article 912 (n. s.) from the Michigan Agricultural Experiment Station*]

The Lixate method of salting pickles is a mechanized version of the brine method. The principal difference is that in the Lixate method the salt can be transported in pipes easily and quickly from one part of the salting station or factory to another. The process which involves the use of the Lixator combines a method of dissolving rock salt without agitation and a method of self filtration. One experiment which was done consisted of a combination of dry salting with rock salt and the Lixate method. In another experiment the Lixate method alone was employed. So far as the bacteriological and chemical data are concerned there was no significant difference between the two methods. The Lixate method involved less labor since there was no salt to be handled but just valves to be manipulated. The brine of a tank of pickles may be increased to the desired strength by withdrawing a small amount of brine from the tank and replacing it with saturated brine. This operation temporarily decreased the percentage of acid and the bacterial count. The withdrawal of small amounts of brine, about 4 percent, apparently had no effect on the curing of the cucumbers since both the acid and bacterial counts quickly regained what had been lost by withdrawing this small amount of brine from the tank.

The Potentiating Action of Sulfonamides on the Brucella Antibody Complement System

HUDDLESON, I. F.

Am. Jour. of Vet. Res. 9 (32): 277-285. 1948. [*Journal Article 917 (n. s.) from the Michigan Agricultural Experiment Station*]

Experimental data are presented in the foregoing experiments which show that certain of the sulfonamides form a highly active bactericidal complex with the specific anti-body complement system. This complex will prevent the growth of and kill *Brucella abortus, suis* and *melitensis in vitro* and *in vivo.*

It has been shown that the effectiveness of this complex in killing bacteria in a test tube or in a body of an infected animal was governed by the number of inactive complement-binding antibody molecules present in blood serum.

A procedure has been developed which either counteracts the action of inactive antibody molecules or possibly converts them into active ones.

Field Applications to Control Spittle Bugs in Michigan

PEDERSON, C. E., AND SHERMAN, FRANKLIN III

Jour. Econ. Ent. 41 (4): 659-661. 1948. [*Journal Article 928 (n. s.) from the Michigan Agricultural Experiment Station*]

A number of materials were tested in 1947 on strawberries, alfalfa and clover against spittle bug nymphs. The results indicate:

1. On strawberries, benzene hexachloride gave nearly perfect control, and there was no evidence of tainting when applications were made at least a week prior to harvest. Rotenone and nicotine sulfate also gave good control. DDT, hexaethyl tetraphosphate, and the DDT with fixed nicotine failed to provide satisfactory control.

2. On alfalfa and mammoth clover, benzene hexachloride gave very good control. The treated alfalfa showed a 14- to 18- percent increase in hay yield when cut 4 weeks after spraying.

Effect of Particle Size of Vermiculite Media on the Rooting of Cuttings

O'ROURKE, F. L., AND MAXON, M. A.

Proc. Amer. Soc. Hort. Sci. 51: 654-656. 1948. [*Journal Article 937 (n. s) from the Michigan Agricultural Experiment Station*]

Exfoliated vermiculite in five different grades, designated as S. F. No. 1, No. 2, No. 3, and No. 4 in descending order of particle size and one grade of common propagating sand were compared as rooting media for softwood cuttings of many ornamental deciduous shrubs under both normal and humidified greenhouse conditions. Results were tabulated according to index values arbitrarily assigned to individual cuttings based on the degree of rooting within a specific time. Cuttings of the majority of plant species responded best with the No. 2 grade, closely followed by the No. 3 grade, although a few species rooted well in the coarser grades and several others in the very fine grade. Nearly all species rooted better in any of the vermiculite grades than in sand.

Studies of the Protein Requirements of Women

OHLSON, M. A., BREWER, W. D., CEDERQUIST, D. C., JACKSON, L., BROWN, E. G., AND ROBERTS, H. P.

Jour. Am. Dietetic Assoc. 24 (9): 744-749. 1948. [*Journal Article 966 (n. s.) from the Michigan Agricultural Experiment Station*]

Healthy women of the North Central States eat food from a basic dietary pattern in which the intake of protein and calories is closely related. In order to provide 60 grams of protein per day or one gram per kilogram, careful selection of food is necessary as soon as calories are reduced below 1750 to 2000 per day. On a controlled diet, made up of foods characteristic of the group but eaten in prescribed amounts, 45 grams of protein per day per 60 kilogram woman were required for equilibrium in well nourished college-age individuals. When food was eaten *ad libitum*, 54 grams protein per day were needed. Aging women, consuming food *ad libitum*, required an average of 53 grams protein per 60 kilogram woman. None of these estimates allow for a factor of safety in utilization nor do they provide for the apparent capacity for protein retention in well nourished young women.

Evidence is available that protein intakes from 70 to 90 grams per day protect young women during certain periods of physiological strain. Few adult women of the North Central area eat more than 70 grams of protein per day unless more than 2000 calories are consumed.

The Identification of the Fatty Acids of the Fat from the North American Black Bear

SELL, H. M., TAYLOR, BETTY M., AND MILLER, E. J.

Jour. of the Amer. Oil Chemists' Soc. 25 (11): 416-417. 1948. [*Journal Article 970 (n. s.) from the Michigan Agricultural Experiment Station*]

A study has been made of the identification of the fatty acids of the fat from a North American black bear. The methyl esters of the fatty acids from the fat were prepared and fractionated through a Stedman Column. Myristic, palmitic, stearic, oleic, palmitoleic, and linoleic acids were identified by the melting points of the p-bromophenacyl ester of the saturated acids and the hydroxy and bromine addition compounds of the unsaturated acids.

Isolation, Cultivation and Identification of Brucella

NADOLSKI, E. B.

Michigan Bul. for Med. Technologists. 1 (1): 10. 1948. [*Journal Article 989 (n. s.) from the Michigan Agricultural Experiment Station*]

Brucella organisms are more readily isolated from human blood by employing a fortified Bacto-tryptose broth and incubating the culture under 10-percent CO_2 tension.

Preparation of the medium and the technique used in obtaining the proper gaseous tension are described.

Milk samples should be allowed to stand in a cold room for 24 hours to allow the cream to rise to the surface. The cream carries with it the majority of organ-

isms in the milk. 0.1 to 0.2 ml. samples of the cream are put on tryptose agar plates. The plates are incubated in 10-percent CO_2 at 37° C. for 4 days.

Isolated *Brucella* colonies are identified by the use of thionin and basic fuchsin dye plates and H_2S production. The latter is determined by the use of a strip of lead acetate paper placed inside a tube which contains a culture of *Brucella* streaked on a liver agar slant.

Very few workers have succeeded in isolating *Brucella* from the feces and urine of infected human beings.

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